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Computer Design of the Regulating Working Element of the Channel Cleaning Equipment

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ABSTRACT Cleaning devices of channel systems used for irrigation of agricultural plants and mechatronic parts regulating their operations were analyzed, the issues of automation of construction design, measurement and management in this field were examined and the purpose of the work was determined. As the goal of the work, the issue of automation of the construction design, technological measurement and management process of the working body for efficient cleaning of small and medium-sized concrete-covered channels, bathtubs from sludge and weeds was set. A complex scheme of information, algorithmic and software support for the automation of the design, technological measurement and control of the mechatronic parts of the working body used for cleaning the channel and bathtub was proposed, and the issues of logical modeling and simulation of the drawing of 2- and 3-dimensional images of the working body were solved. Algorithms were developed using the production modeling method to automate the process of technological measurement, implementation and management, which accurately regulates the operations of the working body of the mechanical device of complex construction. In Solid Edge 2D, 3D software environments, the determination of the geometric shapes of the individual mechanical parts of the channel cleaning unit with a milling cutter, their sizes and types of materials is ensured, and the algorithm was developed using the logical modeling method. For the automation of the structural design process, the information security of the mechanical parts of the application object and the elements of the new design milling cutter device was created for the management of the database of drawings.

KEYWORDS Channels and tubs; milling element; automated design; technological measurement; regulation and administration; constructor design; Solid Edge 2D, 3D.

I. INTRODUCTION

A. ACTUALITY OF THE PROBLEM

As known, in many developed countries of Europe and Asia, a large network of irrigation channels is used to grow national economic lands and ensure their high productivity. Long-term use of irrigation channels in large regions with national economic plants without modern mechanical cleaning technologies, the process of their automation and control, as well as without the use of automated design tools for channel structures, leads to a decrease in productivity during cultivation, water supply flow and complicates their operation when irrigating plant plantations. Existing problematic issues in the field of melioration, the use of cleaning devices on water supply channels for plant plantations in European countries [1], is also a global problem for Azerbaijan, since it, being an agrarian country, has a network of water channels, where control over the cleaning of these channels is required, as well as the use of modern methods of automation and control of the process of functioning of cleaning devices and their working bodies. In our country, more than 88% of agricultural crops are grown on irrigated lands. For this purpose, a large number of small and medium-sized channels are designed and built on irrigated agricultural lands. An analysis of the existing structures, materials and routes of cleaning communication means that exist today shows that they are outdated and require constant reconstruction [1, 2]. Periodic cleaning of concrete channels is one of the important conditions for maintaining them in a productive condition. These jobs are hard and labor-intensive and require a lot of manpower and resources. Currently there are about 1.47 million. Yes, the land is irrigated. 21% of these lands are irrigated by open covered channels, 53% by open ground and 26% by closed covered irrigation networks [3].

Currently, the bulk of agricultural products produced in the republic are grown in the regions.where channel systems are widely developed. Considering this point, an important issue is the use, cleaning and repair of existing irrigation channel systems, collector and drainage networks. To obtain a high yield, it is necessary to ensure the water demand of agricultural products and, above all, the normal water consumption of channels at a high level. For this reason, it is important to periodically clear irrigation channels of silt and weeds. Currently, special-purpose mechanisms for cleaning concrete-lined irrigation channels from silt and weeds continue to be improved. For this reason, there is a great need to create high-performance, maneuverable, lightweight, easy-to-repair sewer cleaning machines with an active working body and their use in agriculture. To determine the exact design dimensions and select the geometric shapes of the mechanical parts of a sewer cleaning device of complex design, it is necessary to use algorithmic support methods and modern software for computing design process [4, 5, 6].

Thus, given the relevance of the issue of water supply and irrigation of national economic plants in the mountainous and lowland regions, more modern technical means using high-quality materials and more reliable structural forms are required. At the same time, more modern approaches are required to develop new design tools, intelligent methods for searching and selecting the necessary materials, structural forms of cleaning agents, communication channels and auxiliary devices. In this regard, the purpose of the material and the main research questions were determined [7, 8].

Currently, an important issue is emerging, such as the creation and application of new technologies, machines and suspension devices related to the reconstruction and improvement of channels and their cleaning infrastructure. The lack of measurement and automatic control systems for periodic cleaning of bathtubs and drains increases the interest in this field and there is a great need to develop new innovative management tools in the channel cleaning working bodies. The working body to be implemented simplifies the work by cleaning the tubs from sludge and weeds, and by changing the direction of discharge of the cleaned sludge, it directs it to the road and collects it in a special container. The utility often eliminates silting, as in the previous system, the treated mass was dumped on the curb, and then during rainfall, the discarded mass was washed back into the sump and culvert, resulting in re-silting.

As a result of the conducted scientific research it was established that during the operation of channels for water supply of national economy due to the influence of natural and industrial pollution large water losses and siltation are allowed. Water losses mainly occur as a result of water seepage into ground channels when the groundwater level rises above the norm and the territory adjacent to the channel is flooded. As a result, irrigated lands become polluted and the productivity of agricultural lands decreases [3].

To solve this problem, i.e. to prevent losses during water supply of irrigation channels, it is necessary to thoroughly ensure the process of automation of design [4, 5] starting from the technical task for laying concrete pavement and the introduction of various types of cleaning equipment to their practical implementation. Among such pavements, reinforced concrete pavements with the use of adjustable milling cleaning devices are the most widespread. Despite the fact that their construction costs a lot of money, unlike ground channels, the efficiency of irrigation channels with concrete pavement is very high ($\eta=0.92$). Depending on the purpose of the channels, parameters, and operating conditions, the thickness of the concrete coating is taken to be up to 15 ÷ 25 cm.

According to the cross-section profile given in [4], the possible thickness of the concrete coating is - *0.10; 0.15; 0.20* m; the width of the channel bottom is $b_d = 15\ m$; the depth of the channel is $h_k = 5\ m$. Concrete coatings are laid on irrigation channels when losses caused by water seepage into the channel exceed the permissible norm, as a result of which the groundwater level rises and crops located near the channel are flooded, and the following condition must be met [6]:

$$q_b \le 11{,}6Q,$$

$$h \le \Delta h,$$

where – q_b-leaks in channels, permissible rate of water loss in this case - l/(sec*km); Q - water loss in underground channels, 1 m - m³/day; h - depth of groundwater crisis, (m); - depth of groundwater rise as a result of seepage into underground channels, m.

The designated service life of concrete pavements until complete restoration is approximately 40...50 years, asphalt concrete pavements - 15...20 years.

The quality of concrete pavement is determined by the following condition:

$$K_p \le K_b \text{ or } P_b \le P,$$

where K_p - the conditional coefficient of coating leakage, cm/sec; K_b - the permissible coefficient of coating leakage, m/sec; P - the conditional damage of the coating, %; P_b - the permissible damageability of the coating, %.

To ensure long-term operation of water supply channels with concrete coating, cleaning devices with an adjustable working element are used. In this regard, the article sets the goal of developing an automation system for the design of a cleaning device with provision for information measurement and adjustment of the working element.

In order to overcome this problem, the aim of the article is to design a new design of a milling-type active working body with a light element for efficient cleaning of small and medium-sized concrete-lined channels from silt and weeds, to ensure the selection of information-measuring elements and the automation of the management process.

B. THE MAIN RESEARCH TASKS OF THE PAPER

1. Creation of a complex structure scheme that ensures the automation of the design process of the cutter-type active working body of the channel cleaning device;

2. Development of the algorithm that ensures the automation of the information-measurement and management process of the milling-type active working body of the channel cleaning device;

3. Development of an algorithm for the improvement of working capacity of the working parts of the channel and tub cleaning device, the implementation of technological measurement and management procedures;

4. Modeling of designer procedures using SolidEdge of parts that regulate the working body that cleans channels and tubs.

II. CREATING A COMPLEX STRUCTURE SCHEME THAT ENSURES THE AUTOMATION OF THE DESIGN PROCESS OF THE WORKING BODY FOR THE WATER CHANEL CLEANING DEVICE

The process of drawing up sketch project documents is programmed through the Solid Edge 2D, 3D computer graphics system to ensure the effective implementation of the design works of the milling-type active working body (MTAWB) of the channel cleaning unit (CCU). In order to automate the graphic mode procedures of the sketch design process, a joint activity structure [9] of drawing, certification, creation and animation of 2- and 3-dimensional images of CCU MTAWB, creation and animation of a graphic database is created (Fig. 1).

Based on the software interface of the automated design, the 2-dimensional frontal, top and side drawing procedures of the structural design are carried out step by step. Constructor design operations such as determination of dimensions of individual mechanical parts, determination of material and its degree of processing, drawing and editing of CCU are performed step by step [10].

Solid Edge 2D, 3D program environment is formed from the automated design of the application object in graphic mode software procedures - drawing 2, 3-dimensional images and animation operations [11]. The creation and storage of the corner stamp and specification table is ensured for the organization of the database of the drawn images of CCU and MTAWB. The mentioned complex constructor and information provision are organized in the architecture of the automated design system [12]. The following design functions are implemented for the efficient organization of the architecture of the automated design system of CCU and MTAWB.

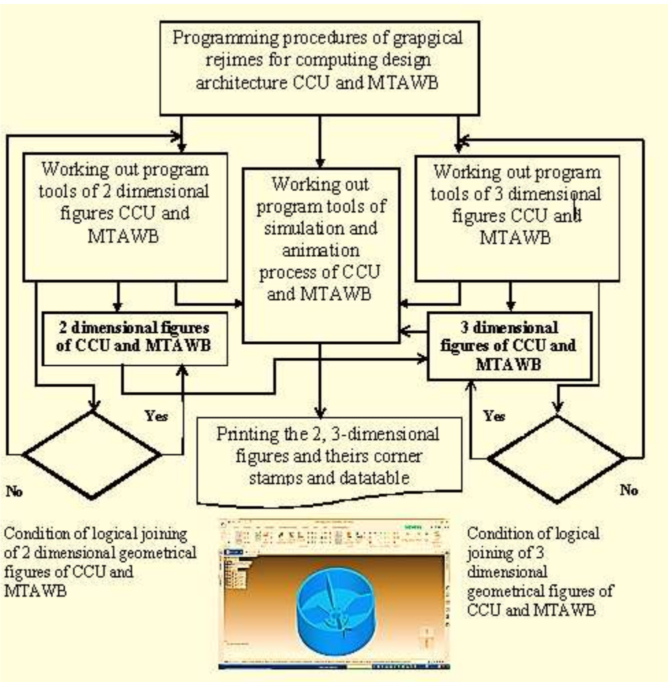

Figure 1. Interfunctional structure of graphical mode software procedures of the constructor design process of CCU and MTAWB

1. Activation of the Solid Edge 2D, 3D system and appropriate naming of the drawing object.
2. Drawing a generalized line of CCU and MTAWB in Solid Edge 2D. Selecting a 2-dimensional coordinate system for drawing the application object and drawing boundary lines, corner stamp in A1 format and setting the appropriate drawing scale.
3. Working drawing of the 2-dimensional generalized descriptive system of the prototype project selected at the technical proposal stage of CCU and MTAWB and determination of the geometric shape of the construction, internal and external dimensions, and selection of material type.
4. Depending on the degree of complexity of the application object, providing additional views corresponding to the 2-dimensional generalized image and creating a specification database.
5. Determining the main overall dimensions of the image and coding each mechanical part based on the standard scale dimensions depending on the real dimensions of the CCU and MTAWB.
6. Database management of specification table, line corner stamp, geometric figures, position coordinates, material types, etc. searching and selecting key query input data. Saving graphic data based on the names of the mechanical parts entered.

III. DEVELOPMENT OF A LOGICAL ALGORITHM FOR AUTOMATION THE INFORMATION-MEASURING AND CONTROL PROCESS OF THE WORKING BODY OF THE CLEANIG DEVICE FOR THE WATER CHANNEL

The throwing tool of the proposed working body is such that it throws the excavated and cleaned mass to the designated throwing distance. In order to achieve this, a special algorithm of changing the parameters depending on each other has been developed, by means of which technological measurements are made and controlled by the controller in the working process of the device [13, 14].

Based on the established algorithm, the control functions of the controller are performed in a logical sequence (Figure 2). Under the given condition ($0<\alpha\leq 15$), signals A and B are compared as follows:

IF A=B THEN Comparison of signals again returns to the conditional operator,

IF A>B, THEN the solenoid (which controls the hydraulic cylinder valve solenoid) corresponds to 1,

IF A<B THEN signals solenoid 2.

This process takes place in the distance between the transmitters and the process is repeated again.

The process inside the controller is as follows:

2 triggers are connected to the milling cutter. These triggers are turned off by separate transmitters, but connected at the same time. One of the triggers turns on the generator, and the second turns on the timer. After that, signals are sent from the generator and timer to the inputs of "owen logic" (controller). Since the controller has a comparison block, it compares the signals from the generator and the timer in each cycle of the milling cutter. The comparison depends on the length between the on and off transmitters.

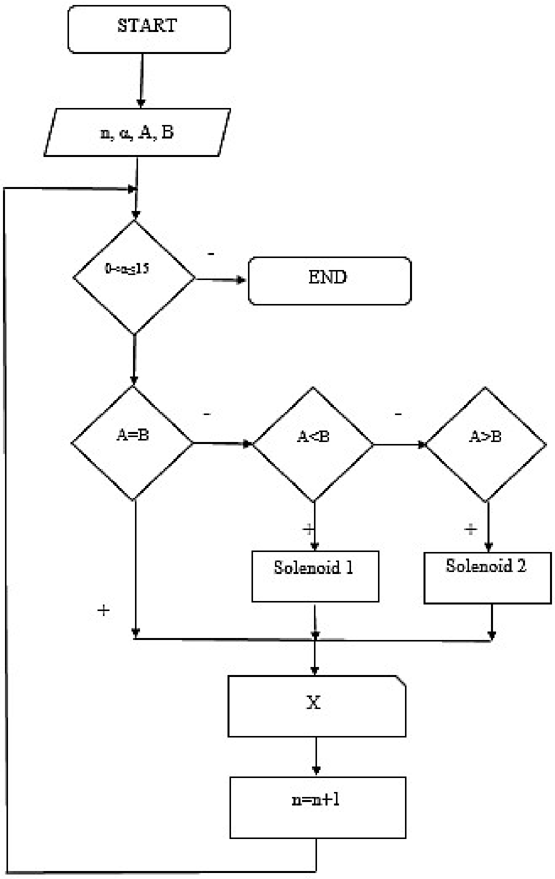

Figure 2. Algorithm for performing the adjustment process of the working body that cleans channels and tubs

As can be seen from the algorithm, when the first start is given, the data *n, α, A, B* are entered into the input block. Here: *n*- the number of cycles of the jumper; *α* – the angle between the initial and final transmitters; *B* - generator signal; *A* - a timer signal.

If the number of cycles of the milling cutter increases, the comparison time decreases. The number of signals is inversely proportional to the number of cycles. On the other hand, the number of signals given by the timer depends on the state of the potentiometer. The comparison block works within 3 conditions depending on the signals (*A=B, A>B, A<B*). When A and B are equal, the hydraulic cylinder does not move. The positions of the transmitters are shown in figure 3.

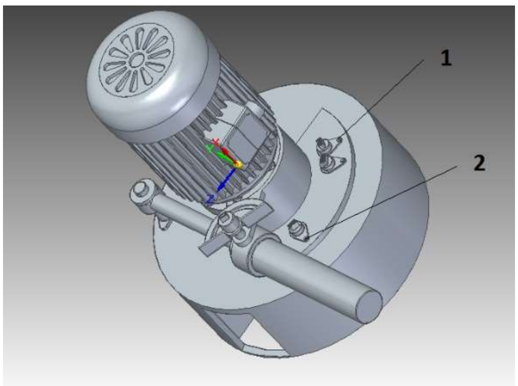

Figure 3. Transmitters of the working body
1- starting transmitter; 2- final transmitter

Based on the conducted theoretical and experimental studies, an algorithmic adjustment was made through the basic, structural and technological parameters of the cutter-jumper type working body for digging channels and tubs [15]. For the first time, management and regulation of the processes performed by the working body was achieved [16].

One of the goals of this work is to make it possible for the milling cutter to throw the soil to the designated throwing distance, depending on the machine's forward speed. In general, the goal is to adjust a few parameters as desired. It was possible to achieve this with the help of special transmitters.

IV. DEVELOPMENT OF AN INFORMATION-MEASUREMENT AND CONTROL ALGORITHM FOR INCREASING THE WORKING CAPACITY OF THE WORKING PARTS OF THE WATER CHANNEL CLEANING DEVICE

In the process of designing the channel and tub cleaning device, especially in the stage of developing sketch projects [17], it is considered one of the important issues to carry out algorithmic research and analyze with computer experiments in order to improve the working capacity of the working parts of the device, to improve their quality. In this regard, a technological analysis of the working bodies of the cleaning device was carried out, and it was determined that an elastic element (a metal brush) is attached to the cutting blades to clean the soil layer (approximately 15...25 mm) between the milling disk and the concrete cover. During experimental work, the effect of changing the length of the steel rods of the metal brush on the power required by the working body, the productivity and the cleaning quality of the channel (Kt) was studied in detail. It was also determined during experimental research that the change in the length of the steel rods of the metal brush has a great impact on productivity and the quality of channel cleaning. As the length of the rods increases, so does the force required by the working body.

Let's build the following algorithm to accurately conduct the experimental study (Fig. 4.).

If the length of the rods up to lsh=0.02 m, the excess strength increases only due to the deformation of the rods, and when lsh>0.02 m, the increase in strength also increases due to the strength required to overcome the friction of the rods on the concrete cover. As a result of the measurements, it was found that the power required by the metal brush is approximately 8-11% of the total power of the working body. At this time, other parameters remain constant.

As a result of the research, it was determined that the change in the length of the steel rods significantly affects the cleaning quality of the channel. The length of the rods is accepted up to lsh=0.02 m. The indicators of dependence on the length of the rods of the metal brush are determined by the following values:

$$V_{ir}=0.09 m/sec;\ V_{chev}=7\ m/sec;$$
$$K_d=0.2;\ Z_k=3;\ L_{at}=6m,$$

the coefficient (K_d), which indicates the quality of purification, approaches the minimum value. The coefficient showing the cleaning quality coefficient (K_d) is determined by the ratio of the cross-sectional area of the sludge remaining in the channel after cleaning ($S_{t.c}$) to the cross-sectional area before cleaning ($S_{l.c}$).

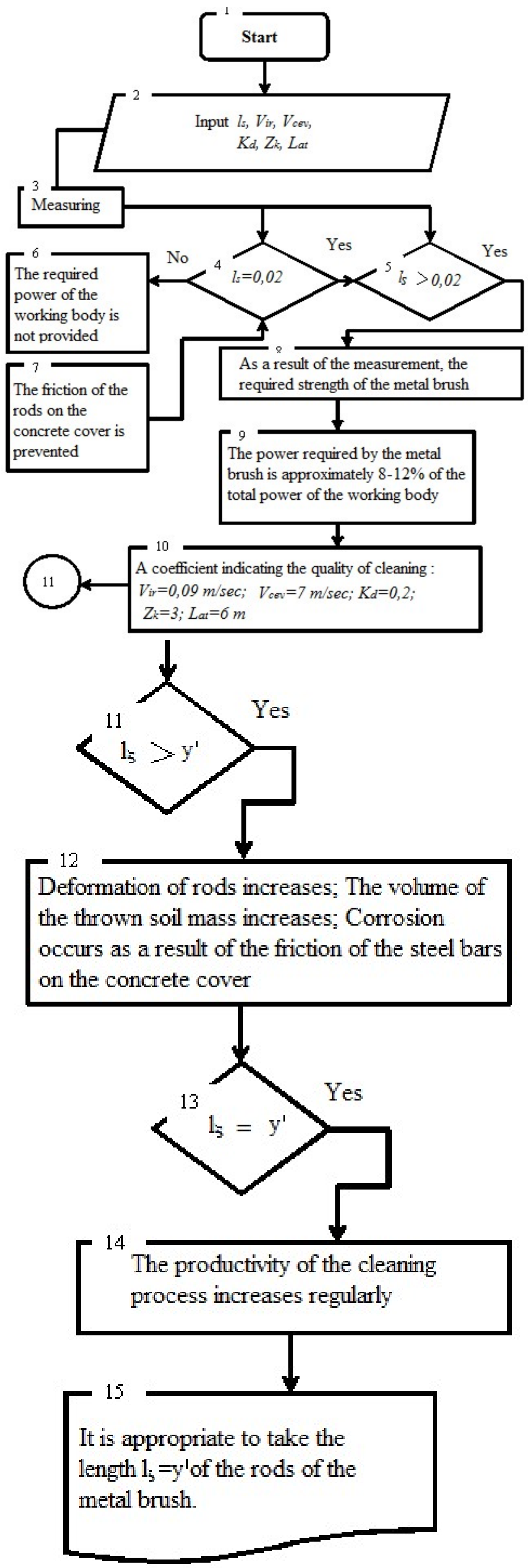

Figure 4. Algorithm for choosing the length of the steel rods of the metal brush, which affects productivity and the quality of channel cleaning

However, when l_s>0.02 m, because the deformation of the rods is large, they cannot completely clean the sludge, and as a result, the value of the cleaning quality coefficient also changes.

During the experiment-research, the effect of changing the length of the rods of the metal brush on productivity was analyzed in detail. When taking the length of steel bars up to $l_s = 0.02$ m, the productivity increases regularly. This increase occurs due to the increase in the volume of the thrown soil mass. However, when the length of the brush is taken $l_s > 0.02$ *m*, that is, despite the increase in the length of the rods, the productivity gradually decreases. As the length of the rods increases, their deformation also increases, and the metal brush loses its ability to work. Therefore, the productivity is gradually decreasing.

Completing the above, we can come to the conclusion that if the distance between the milling disc and the concrete cover is equal to - $y`=0.02$ m or close to it, it is not appropriate to take the length of the rods of the metal brush. Because when lsh > y', the deformation of the brush increases (as a result, productivity decreases), the required power increases, and the cleaning quality of the channel deteriorates, and at the same time, as a result of the friction of the steel rods on the concrete cover, they are eroded. Based on all this, we can say that it is appropriate to take the length of the rods of the metal brush as $l_s=y'$.

The dependence of the power required for the working body on the forward speed of the machine is determined by the following indicators:

$V_{chev}=7$ *m/sec*; $Z_k=3$; $b_d=0.4m$;
$H_k=0.6m$; $a=45$; $b=18.76\%$;
$z=1515$ kg/m^3; $k=180000$ H/m^2;
$K_d=0.2$; $N=0.3725$.

The analysis of the following primary data is required to study the effect of soil moisture on the power required by the working body in the process of cleaning the concrete-covered irrigation channel with a milling cutter:

a - the general state of the cleaning process;
b – condition of the channel after cleaning.

During the study, the effect of soil moisture on the power required by the working body and base machine at different forward speeds was studied. The initial data at different forward speeds are included in the following implication:

Production 1

IF $V_{ir1}=0.05$ *m/sec &* V_{ir2} = 0.09 *m/sec change in soil moisture occurs,*

THEN the power required by the working body of the bathtub is changed.

ADDITIONALLY IF soil moisture is less than 14%,

THEN, because of its strength, its resistance to cutting increases

AND the power required by the working body increases.

IF moisture content is greater than 19%

THEN there are cases of the soil sticking to the blades of the milling machine.

This, first of all, worsens the cutting of the soil and at the same time its free accumulation on the milling blades. Therefore, the required power also increases. The low power consumption required by the working body occurs when the soil moisture is in the range of 14...19%. According to

IF the soil moisture is in the range of 14...19%

THEREFORE, there are no cases of the cutter jumper sticking to the blades of the cutter during the work process

AND the working body is not subjected to additional loading.

When the soil moisture is lower than the range indicated above, the power required by the working body also increases. The reason for this is the increase in the hardness of the soil as a result of the decrease in moisture.

As we increase the moisture content of the soil, its stickiness and coefficient of friction increases to the maximum. The factors indicated by the increase in humidity gradually decrease as a result of the formation of a free water layer on the surface of the soil. This layer of water acts as lubrication between the meeting surfaces. Therefore, the indicators of soil moisture (J_n) during cleaning of the tub are shown as follows:

$14 \le J_n \le 19$ %

IF (J_{n_max}=19%) ≤ {20, 21,...},

THEN, during the operation of the milling cutter, the splashing of wet soil to the edges causes contamination of the working body of the tub and the surroundings.

Thus, we can come to the conclusion that although it is easy to clean soils with high moisture content (more than 19%) formed in concrete covered irrigation channels, such moisture content is not appropriate. Therefore, before starting the cleaning work, it is necessary to dry the channel in such a way that during the work neither the soil sticks to the shovels nor the working body of the tub gets dirty.

During the experimental work, it was determined that additional waste (iron objects, large pieces of wood and stone) is thrown into the channels, especially in places close to residential areas. This complicates the work process of the working body and the movement of the machine during cleaning, and even causes the blades of the milling cutter to fail. This has a bad effect on the working mode of the milling cutter. Therefore, before starting the cleaning work and during the cleaning, the uncleaned part of the channel should be visually inspected and large-sized waste should be removed from the channel.

Changing the number of cycles (n_f) of the milling cutter has a great effect on the energy capacity of the process, the distance of the soil throw and the uniform dispersion. During experimental work, the change in the number of cycles of the milling cutter affects the productivity of the milling cutter. As the number of revolutions of the milling cutter increases, the distance of the soil is also increased. Then the algorithm is written as follows:

Production 2

IF number of cycles n_{f1} = 130 cycles/min

THEN distance of soil throw L_{at}=4.2 m.

IF number of cycles n_{f2}=260 cycles/min

THEN distance of soil throw L_{at}= 8.7 m.

From this we can conclude that when the number of revolutions of the milling cutter is regularly doubled, the distance of the soil throw increases faster.

The distribution of soil in the direction of discharge occurs in a small way. The small particles of the discharged soil are located closer to the channel, and the large particles are relatively far away.

By observing the working process of the milling cutter, it was determined that a part of the soil thrown in a small number of cycles of the milling cutter falls on the edge of the channel. Then the decision-making algorithm is written as follows:

IF number of cycles n_{f3} = 155 cycles/min

THEN, the ground throw distance is $4.7 \le L_{at} \le 6.5$ m.

IF number of cycles n_{f4}=260 cycles/min

THEN distance of soil throw Lat= 8.7 m.

IF number of cycles nfi ≥{n_{f1},n_{f2},n_{f3},n_{f4} },

THEN the Nt.or power used to throw the soil increases.

The peripheral speed of the milling cutter (V_{chev}) is determined according to the required throwing distance of the soil, provided that it has a low energy capacity in the cleaning process:

Production 3

IF number of cycles n_{f5} =100 cycles/min,

THEN power of the working body $N_{t.or1}$ = 3.38 Kwt is required.

IF number of cycles n_{f5} =200 cycles/min,

THEN power of the working body $N_{t.or1}$ = 4.61 Kwt is required.

IF number of cycles – 2 n_f

THEN Nt.or1 → min of the working body increases.

Despite the change in the number of AS cycles by 2 n_f times,

AND V_{ir}=0.09 m/sec

AND K_d=0.2

AND Z_k=3 of the number of spades of the milling cutter productivity is close to 0.

THEN the energy consumption of the process increases more rapidly.

Taking into account the quality and energy performance indicators of the milling cutter, it can be confirmed that the number of cycles of the milling cutter with a diameter of 850 mm should vary between 150...200 cycles/min. In this number of cycles, the working mode of the milling cutter becomes more stable and stable.

Since the distance and uniform distribution of the soil, the energy capacity of the process is ensured by the number of cycles in the range of 150...200 cycles/min, it is necessary to increase the productivity of the machine by increasing the speed of advancement. Studying the influence of the number (Z_k) and shape of the milling cutter blades on the cleaning process is important because the change in the number and shape of the blades directly affects the amount of soil mass accumulated on them, its removal, and at the same time the quality indicators of the process. In the process of experiments, shovels of different shapes were used. During the study, cutting blades of different shapes and numbers are installed on the milling disk.

The change in the number of blades of the milling machine, the increase in the volume of soil accumulated on it affects the productivity of the milling machine at a constant price. Since cutting shovels perform various technological operations, such as both cutting and throwing soil, their shape also has a certain influence on the cleaning process. So, it is more appropriate to use shovels in order to improve the crushing and cutting conditions of the discarded soil. Summarizing all that has been said, we can come to the conclusion that it is advisable to take the number of shovels approximately 3...5.

It is required to be equipped with a modern control system for more efficient execution of the operations of the regulatory tool of the working body used for cleaning the channel and tub with the proposed production method. In this regard, the issues of technological measurement, implementation, selection of controller tools, and research of the general management process with a computer experiment are set. For this, the principle of writing implication commands and logical statements of the production modeling method is applied.

Thus, operations are divided into productions (***production i***) taking into account the specifics of the application object (i.e. technological functions)

IF, based on ***production 1****,* the indicators of the logical expression are given in the intervals of the speed of the execution mechanism of the working body of the tub (V_{ir1} (m/sec) → 0.05 ÷ 0.09 (m/sec)) and the moisture level of the soil (14 ÷ 19 (%)).

THEN select the type of transmitter that can measure the moisture level of the soil that varies in (14 ÷19 (%)) intervals for the *ONDA* automatic control system. Predicate calculus is used to describe the types of transmitters and their characteristics. In this case, the headers of the transmitter characteristics are described as V_i, and their data as X_{ij} [18, 19]:

Sensor type V_{1j}	**Output type** V_{2j}	**Electrical power** V_{3j}	**Mea-sure diapozone** V_{4j}	**Accuracy** V_{5j}	**Mea-sure diapozone** V_{6j}
Modbus, ModBUS RTU X_{11}	Ana-loq X_{12}	24 V X_{13}	Max – 100 % Min – 0 % X_{14}	2÷3 % X_{15}	80 ÷ -40^{0}C X_{16}
Tutum vericisi Water Scout, SM100 X_{21}	Ana-loq X_{22}	6÷12 V X_{23}	Max – 50 % Min – 0 % X_{24}	1÷2 % X_{25}	40 ÷ -10^{0}C X_{26}
Soil-Clik X_{31}	Ana-loq X_{32}	6÷8 V X_{33}	Max – 30 % Min – 0 % X_{34}	3÷4 % X_{35}	40 ÷ -10^{0}C X_{36}
FC28 X_{41}	Ana-loq X_{42}	3÷5 V X_{43}	Max – 36 % Min – 5 % X_{44}	1÷2 % X_{45}	35 ÷ -5^{0}C X_{46}

AND the speed of the execution mechanism of the working body of the bathtub (V_{ir1} (m/sec) → 0.05 ÷ 0.09 (m/sec)) should be selected in the intervals of the type of motor.

Motor type M_{1j}	**Number of cycles (rev/min)** M_{2j}	**Electric voltage** (V) M_{3j}	**Flanes diameter** d_f (mm) M_{4j}	**Power** (Kvt) M_{5j}
SIEMENS 1LE1502-2AC43-4 Y_{11}	1000 Y_{12}	400 Y_{13}	350 Y_{14}	90 Y_{15}
AİP 250 S2 Y_{21}	2100 Y_{22}	350 Y_{23}	270 Y_{24}	75 Y_{25}
AİP80 Y_{31}	270 Y_{32}	300 Y_{33}	40 Y_{34}	3,5 Y_{35}

Based on the conditions of ***Production 1*** and ***Production 2,*** the algorithm for selecting technological measurement and execution elements is established as follows:

IF soil moisture content is taken as (14 ÷19 (%)).

THEN transmitter parameters V_{1j} & V_{4j} should be compared,

AND X_{14} → FC28 type transmitter is selected

AND (14 ÷19 (%)) close to the indicator X_{44} → Min – 5 % Max – 36 %.

IF the speed of the execution mechanism of the working body of the bathtub (V_{ir1} (m/sec) →

if it varies in intervals of 0.05 ÷ 0.09 (m/sec)).

THEN parameters M_{1j} & V_{2j} of actuators should be compared,

AND (V_{ir1} (m/sec) → 0.05 ÷ 0.09 (m/sec)) parameter of Y_{32} to the indicator

the nearest Y_{31} → AIP80 type implementation mechanism is selected.

According to ***Production 3****, the algorithm for selecting an execution element is constructed as follows:*

IF number of cycles n_{f5} =100 cycles/min

AND the power of the engine of the working body is required $N_{t.or1}$ = 3.38 Kwt,

ONDA engine type close to n_{f5} is AIP80

AND its power Y_{35} → 3.5 kW

The production-type model created by this method allows to correctly select the transmitters of technological measurement and the engine of execution for the control system of the process of adjusting the working body of the tub with a milling cutter, and to ensure water purification, taking into account all technological features [20, 21].

V. MODELING OF DESIGNER PROCEDURES USING SOLIDEDGE OF PARTS FOR REGULATION OF THE WORKING BODY OF CLEANING DEVICE FOR WATER CHANNELS

In the process of computing design of the channel cleaning work body, its mechanical and electronic elements [22, 23], it is important to accurately analyze the technological process, determine the types, geometric shapes and sizes of mechatronic parts, select materials, and organize engineering graphic works in order to more efficiently perform engineering work. is considered one. In this regard, 2- and 3-dimensional designer design operations of complex algorithmic and software procedures are determined by logical search, selection, editing and drawing functions [24].

The designer-designer performs the following intellectually designed procedures step by step for processing the mechatronic parts of the proposed new construction working body [25]:

query - search - selection - editing - layout.

Procedures such as separation of mechanical parts into elements, their coding, determination of coordinates are modeled step by step in order to draw a generalized outline of the application object. The 2-dimensional drawing of CCU and MTAWB is divided into standard and non-standard elements [26]. The basis of the standard elements, the mechanical parts provided by the state standard are composed of the following design procedures:

P1: CCUB→CCU body (B) or element_1(standard element);

P2: BC→Body coupling (BC) or element_2 (standard element);

P3: CCUA→CCU axis (A) or element_3 (standard element);

P4: AS →Arrow spring (AS) or element_4(standard element);

P5: CCUF→CCU fairy (F) or element_5 (non-standard element).

Based on the logical combination of standard and non-standard elements selected from the database of mechanical parts of *CCU, a generalized drawing of the device is formed.* For this purpose, the Zade operator is used to realize the combination logical operation [27]:

$$\mu_{A \cup B} = MAX\ (\mu_A\ , \mu_B\ ).$$

For selection of mechanical parts of CCU from the certified database as:

$$M_{\ item1\ \cup element\_2\ \ \cup \ldots\ \cup.\ element\_5} = MAX\ (\mu_{\ element1}\ , \mu_{\ element2}\ ,\ldots, \mu_{\ element5}\ )$$

based on the operator, a 3-dimensional line of the CCU is created.

The elements of the created 3-dimensional CCU, the description of the device is drawn step by step. The 3-dimensional geometric figures of the used *element_i* are combined in the following sequence, and as a result, the generalized figure of the CCU is constructed (Fig. 5):

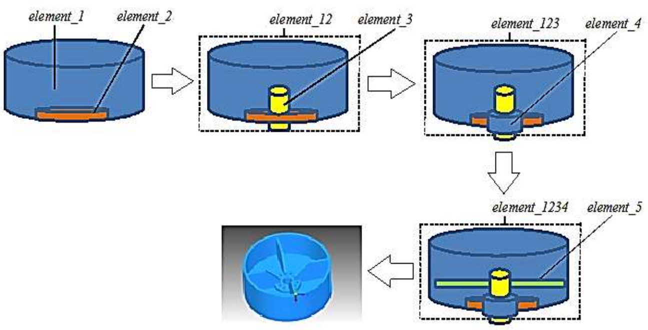

Figure 5. The general outline of the working body of the CCU which is built on the basis of a logical combination

Procedure 1 (P1)

((CCUB ∪BC)↔(element_1 ∪ element_2)) → element_12

Procedure 2 (P2)

((element_12 ∪ CCUA) ↔ (element_12∪ element_3))→ element_123

Procedure 3 (P3)

((element_123 ∪ AS)↔(element_123 ∪ element_4)) → element_1234

Procedure 4 (P4)

((element_1234 ∪ CCUF)↔(element_1234 ∪ element_5)) →element_12345

The mechanical parts of the working body of CCU mainly use software commands of the Solid Edge 3D system for drawing circle and rectangular geometric figures. To perform this constructor procedure, the principle of axonometric representation is required. The logical combination of element_i is realized with broken broken lines. Other intersecting geometric figures are depicted in frontal view with the expectation of symmetry.

Its information provision, in the form of a specification table and a corner stamp is added to the generalized drawing obtained as a result of the drawing of an axonometric drawing by the working body of the CCU.

The general code of the project is formed from the index of the designer's organization (XXXX.), classification characteristic (XXXXXX.), registration number (XXX) and document password (XX). The index of the organization where the designer works is determined by the special code of the region where the enterprise is located. The classification characteristic of the designer consists of 5 parts:

Part 1 (project object class) defines the subject-industry area.

Part 2 - subclasses.

Part3 - the group.

Part 4 - subgroups.

Part 5 - type of tool.

The serial registration number from 0 to 999 is determined by the manufacturer for each specific instrument and model. The password is considered to be the main conditional sign of the constructor document. For example, a drawing overview, a dialing drawing might be described as ABQD.061341.021. or ABQD.061341.021.YC.

At the sketch design stage, the software development process of the corner stamp of the drawing is carried out step by step:

1st stage: The generalized description of the project and the descriptions of individual parts are selected from the graphic database (GDB) and the program block of the corner stamp of the line is activated (from the "System types" menu block of the general program interface of CCU) and the process of entering its data is started;

2nd stage: FS- of the project's author, head, norm controller and approving legal entities is entered, signed electronically, dates are recorded and stored in memory;

3rd stage: The general code of the project, the name and the name of the applied enterprise are entered into the activated cells and stored in the memory;

4th stage: The format of the sheet, scale of the line, type of material and mass indicators of the object are entered in the appropriate cells and stored in the memory to ensure the drawing of the project image;

Stage 5: The finished template of the specification table is activated according to the numbers of the parts of the drawing. The codes, names, quantity, material and other additional information of the parts of the drawing are entered in the cells of the specification and stored in memory.

In order to check the dimensions of the 2-dimensional drawings of individual parts of the working body of the CCU, the variation of the input data of dimensions is carried out in the process of drawing mechanical parts in A3 and A4 formats. By changing the input data, the speed of the moving milling cutter of the device is adjusted. In the example of CCU, when the 2-dimensional image of the axle is built, depending on the overall shape of the body, the exact dimensions of the coupling and the axle, the types of springs mounted on the axle are selected. At the next stage, the drawing of the free-rotating milling line on the axis of the working body of the KTQ is performed in the Solid Edge 3D system (Fig. 6) and its geometric shape, dimensions and view projections are checked by experiments.

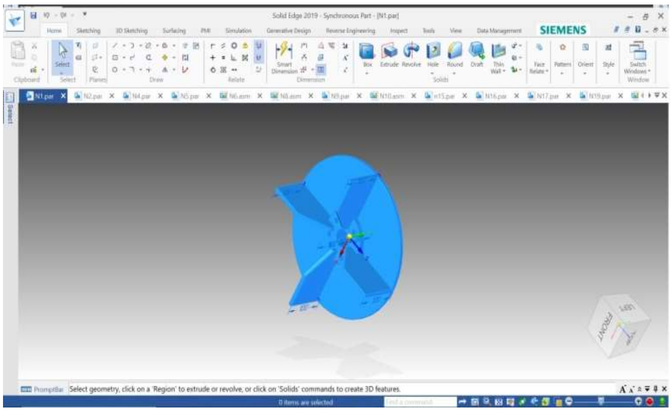

Figure 6. 3D rendering and animation modeling of the milling cutter of CCU in the Solid Edge 3D system

By drawing the image of the milling-type working body of CCU in Solid Edge 3D, simulating the dimensions and geometric shapes of individual parts, it is possible to obtain the results of computer experiments for more accurate design.

VI. RESULTS

On the basis of the task of the papaer, process automation of the construction design process of a milling-type active working body with a light element for efficient cleaning of small and medium-sized concrete-covered channels from silt and weeds are provided.

It was proffered a complex structure scheme that ensures the automation of the design process of the milling-type active working body of the sewer cleaning device.

It was developed of a logical algorithm for automating the information-measuring and management process of the working body that cleans the channel and bathtub.

It was worked out algorithm for choosing the length of the steel rods of the metal brush, which affects productivity and the quality of channel cleaning.

During the research, as a result of checking the effects of soil moisture on the working body at different speeds with experiments, the effect of the power required by the main machine on the logical model was studied. A database and knowledge base of technological measurement and implementation elements selected for the application object has been created.

It was proffered the general outline of the working body of the CCU which is built on the basis of a logical combination.

It was a model of the simulation 3D constructor design procedures of the working body of the channel and tub cleaner using SolidEdge.

VII. CONCLUSION

1. A complex structure scheme was proposed that ensures the automation of the design process of the mill-type active working body that cleans the channel and bathtub;

2. An algorithm has been developed that ensures the automation of the information-measurement and adjustment process of the control system, which ensures more efficient operation of the milling-type active working body of the channel cleaning device;

3. A production-type algorithm was developed for the implementation of technological measurement and control procedures to increase the working capacity of the working parts of the channel and bathtub cleaning device;

4. The engineering-design procedures of the mechanical parts regulating the working body that cleans the channels and tubs were modeled using SolidEdge and checked by computer experiments.

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