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Cleaning of meliorative channels using various types of work equipment machines

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Abstract. The article describes zones with a predominant type of melioration depending on the territorial location of the land being improved. It provides a brief classification of channels based on their structural features, cross-sectional shape, flow capacity, and technical and operational characteristics. Channels are the main elements of meliorative systems. Ensuring the quality of channel operation with the required flow capacity guarantees the effective operation of the entire meliorative system. The typical deformations of channels that arise during operation are described, as well as factors that affect their flow capacity, such as sedimentation, siltation, and vegetation growth, including shrubs and small trees. Channel cleaning machines used for cleaning and restorative work on meliorative system channels are presented, along with their design features for cleaning channels of various types and cross-sections. Channel cleaners are described that operate as both periodic and continuous action machines, which most effectively and qualitatively clean the bottom and slopes of channels in various meliorative systems. The article also explains how the efficiency of channel cleaning and subsequent quality of the meliorative system can be increased by using different sets of channel cleaning machines, including various machines with different working tools, sizes, and quantities. The choice of the number of machines is directly related to technical and economic indicators: the use of a large number of machines may be economically impractical, while using a minimal number of machines will not provide the required cleaning. Therefore, it is important to choose the optimal number of machines of different sizes and shapes to form a separate set.

1. Introduction

The territory of the Russian Federation can be conditionally divided into two zones from the point of view of carrying out meliorative works: the drainage zone and the irrigation zone. The drainage zone includes territories with an excess of marshy areas that require seasonal removal of excess moisture while strictly observing the required water regime. This is predominantly the "northern" territories, including the Central Federal District, Northwestern Federal District, and Volga Federal District of the European part of Russia. The irrigation zone includes the "southern" territories, primarily the regions of the Southern Federal District and the North Caucasus Federal District with the Stavropol Territory. It should be noted that some regions of the country are classified as areas of risky agriculture, which is approximately 70% of the territory.

In some regions, both drainage and irrigation may be carried out, often due to seasonal and climatic conditions. During flood periods, excess water needs to be discharged, while during drought periods, water needs to be conserved. In such cases, a system of dual regulation is used. Different methods with different water movement elements are used for drainage of territories and irrigation of agricultural lands, such as drainage systems, drip irrigation, etc. The use of open channels for conducting drainage melioration on agricultural lands has a certain disadvantage, namely a reduction in the area used for agricultural land. To avoid such problems, closed drainage is used in meliorative systems. However, channels remain the main element for removing moisture in drainage systems and for supplying a large amount of water in irrigation systems [1-3].

Usually, the cross-sectional profile of a canal has a trapezoidal shape. Irrigation canals have a relatively larger capacity than drainage canals. Small rivers serve as natural drainage canals. The construction of canals depends on the volume of water transported per unit of time, the type of soil in which the canal is built, the purpose of the canal, and its formation on a particular territory. Also, the geometric parameters of the working tools used to lay the canal are taken into account. In addition to trapezoidal canals, there are also parabolic canals whose shape is closest to the cross-sectional profile of natural drainage, that is, rivers.

Drainage channels can be either with a fixed bottom or an unfixed bottom within an earthen body. Channels with a fixed bottom make up only a small part.

In the design of land reclamation systems, a sequential command formation is observed, in which the water level of the higher order is higher than that of the lower order.

2. Research methods

This article presents materials obtained through empirical research methods such as observation, comparison, measurement, and modeling of systems for the formation of complexes of channel cleaning machines. Channels have a bottom and slopes in cross-section, with a berm formed at the top, along which channel cleaning machines can move. Channels can be built in excavations as well as embankments. The slope angle is determined based on the water flow rate and the type of soil in which the channel is laid. In this sense, channels with a trapezoidal profile are more convenient than parabolic ones when selecting the type of working tool for cleaning operations.

During the operation of drainage channels, there is a change in the initial structural profile due to the appearance of deposits, silt, vegetation, and small bushes. Usually, when designing working equipment for channel cleaning machines, as well as for channel diggers, the depth of the channel is taken as the main parameter. However, studies of the condition of drainage channels show that the distribution of deposits and silt along the length of the channels is often extremely uneven. In such cases, the thickness of the deposits becomes the main parameter for designing working tools, and during the operation of the channels for 2-3 years, this parameter can be equal to 0.15…0.25 m.

The main reasons for deformation and reduced capacity of irrigation canals, especially during the initial period of operation, are erosion, silting, and overgrowth. In addition, low temperatures, particularly in clay soils, can also have an impact. Other factors include additional loads from riders and soil subsidence (including loess soils, which are most common in Central Asia) [4, 5].

There are canal cleaning machines that differ in their operating mode, either periodic or continuous, the type of working body - passive or active, and the drive of the working equipment - hydraulic or cable-block. The working equipment can be non-revolving or revolving and can be equipped with a tracked undercarriage. The use of a pneumatic wheel undercarriage with a non-revolving working equipment at the back is not very effective for cleaning canals. The most efficient canal cleaning machines from a technology perspective are tracked machines with a revolving working equipment. Milling and rotary designs are usually used as the working body for continuous action canal cleaners. Such machines have high productivity and are in demand today. The disadvantage of such machines is the inability of the rotating working body to provide the initial geometric dimensions of the canal [6].

Periodic channel cleaning machines include bucket channel cleaners. They are represented by machines that work from the channel's berm, as well as intra-channel machines that move along the channel axis. Periodic channel cleaners are somewhat inferior to continuous action channel cleaners in terms of productivity, but they have high quality of work. Especially in this sense, a channel cleaner with a bucket on a rigid guide stands out, which provides high-quality cleaning work on channels with both fixed and unfixed bottoms (Figure 1).

Figure 1. Channel cleaner with bucket on rigid guides.

This machine with side-mounted equipment operates positionally from a berm. The equipment consists of a suspended telescopic boom, at the end of which a guide structure for a bucket is attached (figure 2). The bucket is moved along the guides, which are two channels, by means of hydraulic cylinders and a high-speed four-fold tackle [7].

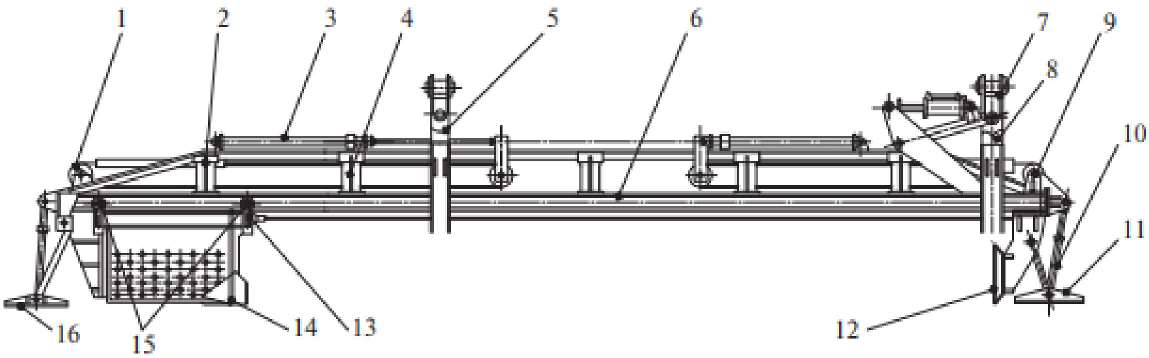

Figure 2. Working equipment with longitudinal movement of the bucket along the channel axis: 1, 2, 9 - end blocks; 3, 7 - cylinders for moving the bucket; 4 - frame of the working equipment; 5, 8 - front and rear telescopes of the boom; 6 - guiding beams; 10 - screw rod; 11 - front movable support; 12 - supporting shield; 13 - traverse; 14 - working body (bucket); 15 - roller supports of the traverse; 16 - rear movable support.

A channel cleaner is a channel repair machine designed for the technological process of cleaning channels, clearing the channel bottom of sediments up to 3 m deep and up to 0.8 m wide at the bottom.

A wide range of natural backgrounds has been fixed on which the channel cleaner can operate. The machine reliably cleans channels with sediment thicknesses ranging from 0.05 to 0.25 m. The presence of water in the channel, as well as the type of sediment and soil conditions, do not significantly affect the quality of cleaning. The technological process provides not only cleaning of the bottom from sediments but also the removal of bottom vegetation with the destruction of its root system.

Laboratory tests of the working body of the channel cleaner were carried out in actual size. The studies showed the effectiveness of the working body design when excavating soil thicknesses from 0.05 to 0.15 m. Within such limits, the sediment thickness usually lies between cleaning periods of 1-2 years. Figure 3 shows the operation of the bucket in actual size under laboratory conditions.

Figure 3. Laboratory tests of the bucket of the channel cleaner in actual size.

The performance of the channel cleaner with a bucket on rigid guides [m^3/h] for a periodic action machine is determined by the formula:

$$\Pi = q \cdot n$$

where q – bucket capacity, m^3;

n is the number of cycles per hour, $n = \frac{3600}{T_c} = \frac{3600}{t_1+t_2+t_3+t_4}$, Where T_c is the cycle duration, t_1, t_2, t_3, t_4 are the durations in seconds of the bucket digging, lifting and unloading, machine movement to a new position, and bucket lowering into the channel, respectively. The cycle duration depending on the depth of the channel can be within the range of 40 to 55 seconds. The productivity of the machine for cleaning unconsolidated channels with a 0.25 m^3 capacity bucket is 20-28 m^3/h or 200-400 m/h.

3. Results and discussion

Cleaning of drainage channels cannot be carried out by only one type of machines of a certain size. Taking into account the accompanying operations, a complete cleaning of the channels is carried out by a complex of machines, containing machines of different types and a certain quantity of them. The content and quantity of machines in one complex is determined by the types and sequence of operations performed.

For example, during the overhaul of irrigation canals, the following operations must be performed: trimming of slopes, removal of sediments and vegetation from the bottom and slopes, collection and loading of sediments, debris, and vegetation from the bottom onto the embankment, and transportation. Depending on the types of work, the complex may include a channel trimmer, channel cleaner, bulldozer, excavator, and dump truck. The functions of the bulldozer and excavator can be performed by a wheeled excavator with a backhoe and bulldozer blade.

Thus, depending on the types and sizes of machines, a large number of canal cleaning complexes can be formed.

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4. Conclusions

The main task in such a situation is to determine the most optimal set of machines. To solve such a problem, a systemic approach is necessary, taking into account the most important criterion. When cleaning canals, the most important criteria are the quality of canal cleaning, which ensures the full functioning of the reclamation system. Technical and economic and technical and operational indicators are also important.

One of the ways to solve the problem of choosing the most optimal complex of channel cleaning machines is to use Dijkstra's algorithm. This algorithm is often used to determine the shortest possible paths. In the case of choosing the most optimal complex of channel cleaning machines, the criterion parameter can be selected as the minimum energy consumption [8-10].

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