FORMATION OF APPROACHES TO CLEANING RECLAMATION DRAINAGE CHANNELS FROM SEDIMENTS, SILTATION AND VEGETATION

Serik Toigambaev[1], Khamzat Abdulmazhidov[1], Arman Abenov[1],
Shakizada Niyazbekova[2], Sabina Maharramova[3]

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[1]Russian State Agrarian University – Moscow Agricultural Academy named after K. A. Timiryazev, RGAU–MSHA, RUSSIA
[2]Moscow Witte University, RUSSIA
[3]Architecture and Construction University, AZERBAIJAN
shakizada.niyazbekova@gmail.com

Abstract

The article is devoted to the issues of cleaning and maintaining the channels of the reclamation drainage system in a working condition. During the study, the general condition and characteristics of the reclamation channels of the drainage network were analyzed, as a result of which it was concluded that the volume of sediments, siltation and vegetation in the channels increased in the absence of maintenance operations, which in turn leads to a decrease in the channel capacity and flooding of agricultural fields. At the same time, the study showed that the proportion of channels in the drainage network, sediment volumes in most channels range from 0.02 to 0.10 m3 per 1 m length, which corresponds to a chip thickness of 5...15 cm. In the course of the work, factors preventing the maintenance of the design depth of drainage channels were identified, which are mainly associated with the increasing volume of sediment and siltation in the absence of canal maintenance operations. The study proposes designs of working bodies of channel cleaning machines moving on rigid guides strictly in a straight line along the axis of the channel, which are capable of cleaning channels both with fixed bottoms and slopes, and without their attachment. The analysis of the stress state of the elements of the new working bodies is presented. In conclusion, the study presents the main conclusions and results of the work carried out.

Keywords: drainage channels, sediments, siltation, vegetation

I. Introduction

Cleaning of reclamation channels of the drainage network is very relevant, since it allows us to solve the important task of ensuring the normal functioning of the entire reclamation system as a whole.

During operation, sediments, siltation, herbaceous and shrubby vegetation appear on the bottom and slopes of reclamation channels, which definitely affects the operation of the system: firstly, the channel capacity is disrupted; secondly, the design depth of the channel, calculated for a specific agricultural field on which a particular crop is grown with a certain drainage rate, it becomes smaller and the site is subject to flooding and an increase in the groundwater level according to the depression curve

All this affects the yield of the agricultural field. The main tasks of agricultural land reclamation are to provide the cultivated crop with optimal water, air, nutrient and thermal

conditions. If there is a lot of water in the field, then the plant may die from excess water and lack of air, or another situation is possible during a drought, the plant may also die from lack of moisture.

Therefore, it is important to maintain the design depth of drainage channels by performing their timely cleaning from sediments, siltation, herbaceous and shrubby vegetation. The most advanced drainage systems with open channels are currently operating in the Netherlands.

On the territory of the Russian Federation, this is the Kaliningrad Region. Periodic cleaning operations within the framework of canal maintenance operations increase the service life of canals before major repairs. The channels are cared for by various channel cleaning machines, including continuous and periodic machines. Trapezoidal channels have become the most widespread in reclamation drainage systems [1–4].

They can be made in an earthen body with or without mounting slopes. The slopes are fixed on channels with weakly bearing soils, on which it is possible for the upper parts to slide to the bottom of the channel. Drainage channels with fixed bottoms and slopes account for about 20% of all drainage channels [5–6]. Their lesser importance is explained by the large lengths of the channels as a whole. The main characteristics of the drainage channels are presented in Table 1.

Table 1: *Average values of the main characteristics of drainage channels.*

Characteristic	Value
Channel depth	before 2,5 –3,0 m
Channel width along the bottom	0,4; 0,6; 0,8; 1,0; 1,2 m
Channel width at the top	8, 10; 12; 14 m
Laying of slopes	1:1; 1:1,15; 1:5

The purpose of the work is to determine the characteristics and condition of reclamation drainage channels with the proposal of methods and means for their cleaning and restoration.

Materials and methods of research. The research materials were reports on the study of the condition of drainage channels, reports on the use of the PP–303 channel cleaning machine developed at the Department of Reclamation and Construction Works, as well as the Field experimental station of the Timiryazev Academy channel cleaner OKN–0.5 of the Kohanovsky Excavator Plant (now JSC Amkodor) purchased for canal cleaning.

To study the condition of drainage channels, the following methods were used: observation of channels, comparison of the condition of sections of channels of the reclamation system, experiment to determine the stability of channels, measurement of geometric parameters of the operated channel and their comparison with design data, practical physical modeling of the channel and working bodies of channel cleaning machines.

Observation of the operation of reclamation drainage channels of the reclamation system of the Field Experimental Station RGAU–MSHA named after K. A. Timiryazev during the study period of 2–4 years shows that over time sediments, siltation, herbaceous and shrubby vegetation appear on the bottom and slopes of the channels.

The distribution of sediments and siltation is formed unevenly, their greater accumulation is observed at the junction of one channel with another or at the locations of drainage pipes. Grassy vegetation, unlike sediments, is more evenly distributed along the slopes of the canal [7]. In the absence of constant maintenance of the channels without their repairs, the amount of sediment on the bottom and slopes of the channels may increase. At the same time, the cross–sectional area of the channel is violated, most often it decreases, which leads to a decrease in the channel capacity. This is only the visible part of the state of the channels at this stage.

For a clearer understanding of the problem of sediment and siltation layers increasing over time, it is necessary to find out the original reasons for the construction of canals. Drainage

channels are necessary to drain excess water during the flood period. In addition, channels are necessary to maintain the drainage rate of various crops according to the depression curve.

With an increase in the amount of sediment and siltation, the groundwater level rises, while the design water level in the channel is violated. In general, in agricultural land reclamation, for the normal growth of crops, it is necessary to ensure optimal values of water, air, heat and nutrient regimes. If there is an excess of water or a lack of it, the plant may die.

In the process of cleaning channels, there may be situations when the operator of the channel cleaner uses a bucket working body to develop sediments and soils below the design water level, while reducing the drainage rate, which can lead to a lack of moisture for the cultivated crop.

Each crop grown in the drainage zone has its own drainage rate (cm from the surface): perennial grasses for hay, flax 50–60; artificial pasture 65–75; legume–cereal feed mixtures, spring grains (oats, barley), winter rye 60–75; vegetable crops, fodder root crops, hemp 75–95.

On drainage reclamation systems, trapezoidal channels are mainly found in the earthen body without fixing the slopes. Bucket channel cleaners are mainly used to clean sediments and siltation of the bottom and slopes of such channels.

Currently, such a machine is the channel cleaner OKN–0.5 (mounted channel cleaner). Not all reclamation companies have this channel cleaner on their balance sheet, therefore, general–purpose single–bucket excavators with working equipment are often used to restore channels, a reverse shovel with a widened bucket [8, 9]. As is known, such positional machines from the berm of the channel develop sediments on the bottom and slopes in the transverse direction to the axis of the channel.

The situation is different when cleaning channels with a fixed bottom. The use of bucket channel cleaning machines for transverse digging is excluded here, otherwise the fastening elements of the bottom and slopes will be destroyed.

To solve such a set of tasks, the Department of Reclamation and Construction Machinery developed a channel cleaner with a longitudinal movement of the PP–303 bucket along the axis of the channel (channel repairer) for cleaning channels up to 3 m deep (Fig. 2). The main purpose of a rectangular bucket is cleaning the fixed bottom when other types of machines are not applicable. At the same time, this machine can be used to clean channels without fixing the bottom and slopes. In this case, a replaceable trapezoidal bucket is used.

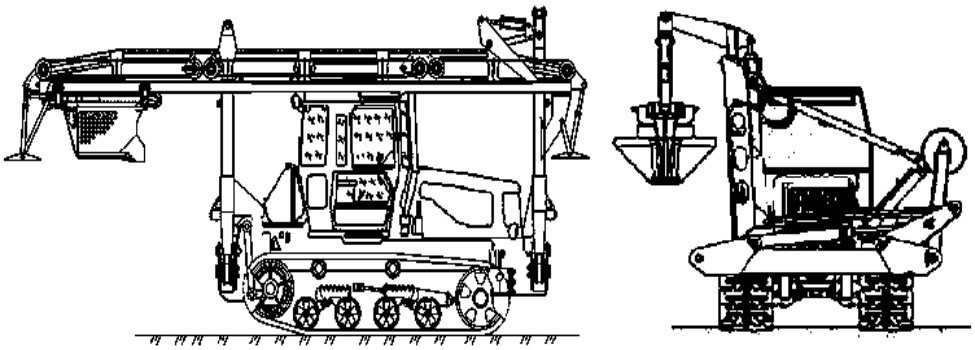

Figure 1: *Channel cleaner PP–303 (side and front views)*

The development and application of new working bodies of channel cleaners with increased capacity requires verification calculations on the strength of structural elements, as well as the stability of the entire machine during the working operation.

Strength calculations are reduced to determining the coefficient of safety margin, for this purpose various computer graphics programs such as Compass, Inventor Pro and others are used. These programs contain modules for conducting strength calculations using the finite element method (FEM).

The essence of this calculation method is to create a three–dimensional structure from a particular material, break it down into finite elements (i.e., create a finite element grid), check

them at specified supports and loads. The margin of safety obtained in this way should be in the range from 1.5 to 2.0 units.

Research results and discussion. The results of the strength calculation of one of the parts of the channel cleaning machine are shown in Fig. 2.

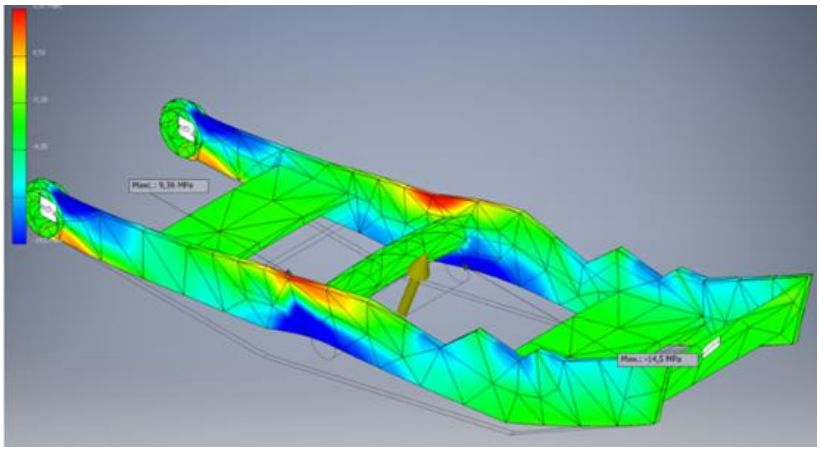

Figure 2: *Analysis of the stress state of the additional element to the channel cleaner bucket*

In cases where the safety factor turns out to be close to the minimum values of the permissible range, for example, 1.51, it is advisable to carry out a refined strength calculation, in which, in order to obtain real values of the safety margin, the dimensions of the finite elements are set much smaller [10-15].

Often, with refined calculations, the values of the safety factor are less than 1.5 – this indicates that the structure does not withstand the specified loads. In the example under consideration, this value is within the permissible limits of 1.9 and therefore there is no need for a refined calculation.

II. Conclusion

According to the conducted studies of the state of reclamation channels, their quantitative, qualitative and geometric characteristics have been clarified. For cleaning channels of a trapezoidal profile, bucket channel cleaners of transverse digging or general construction excavators with replaceable working equipment are most suitable. A reverse shovel with a widened bucket.

For drainage channels with a fixed bottom, it is advisable to use channel cleaners with a rectangular bucket on rigid guides. To clean channels in an earthen body without fixing the bottom and slopes, it is also advisable to use the construction of rigid guides, but with a trapezoidal bucket.

The strength calculations of the elements of the working equipment of the proposed channel cleaner showed a sufficient margin of safety when working with a trapezoidal bucket with increased capacity.

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