Methods of recruiting of mobile repair services and maintenance of machines performing reclamation works

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Abstract. The specifics of reclamation works are associated with difficult conditions for their mechanization. Seasonality of the work requires an increase in the efficiency of using machines, preferably with the absence of their failures. Usually, equipment failures in melioration organizations are eliminated at the place of machine’s work (units) by the on-site repair teams equipped with mobile repair workrooms (MRWs). Cost analysis of the units operation in the technological complex shows that there is an optimal amount of MRWs for performing repair and technical impacts. The authors develop a technique for selecting mobile repair workrooms and their completeness with repair equipment. It justifies the effectiveness of the inclusion of the service department to eliminate machine failures when performing technical works of mobile repair and maintenance services, basing on a car chassis, with special equipment and accessories infrastructure.

1. Introduction
In Russian Federation, works in the field of urban planning and environmental engineering are carried out in difficult climatic conditions. Territorial diversity is characterized by land use zones both with insufficient or uneven precipitation regimes, frequent droughts and hot dry winds, and areas of excessive moisture. The expansion of the urban sphere leads to a change in the ecosystem, and nowadays the issue of reducing the nature’s burden through the development of land reclamation becomes urgent. Raising the standard of living of the population by reducing the territories of the natural complex is already unacceptable; it is required to actively reorient the industrial land plots (often abandoned or naturally depleted) into the category acceptable for organized or private agriculture, through land’s melioration. Reclaimed land, occupying 6% of the arable land, produces up to 65% of vegetable production and potatoes, all rice, about 20% of feed for livestock and other products. The structure of the state management of the land-reclamation complex of the Russian Federation is represented by 80 sub-departments of the Ministry of Agriculture of the Russian Federation in the field of land reclamation with a total staff of more than 17 thousand people [1].
Construction of modern land reclamation is based on the use of a large number of various means of mechanization. The most important task of the technical policy in this area is the complex mechanization of work. The solution of this task requires a continuous increase in the fleet of reclamation, construction and road machines, increase in their productivity and reliability, and improvement of utilization and support of working population. Statistical studies show that a third of the fleet of specialized land-reclamation equipment and vehicles standing on the balance sheet in institutions have a wear rate of more than 75%, and operation of more than 50% of the fleet exceeds the standard operating time.

Under these conditions, an important role is played by technical support measures aimed at maintaining equipment in constant readiness due to operational and service optimization [2–9]. The analysis showed that equipment failures in meliorative institutions are eliminated at the place of work of the machines by the forces of field repair teams equipped with mobile repair workrooms (MRW) [10, 11]. Currently, there are many models of MRWs with different configuration and cost [12]. Various techniques have been developed for their selection, which basically boil down to determining the required number of MRWs. So, recommendations to determine the number of MRWs for servicing logging machines were developed based on the comparison of losses due to machine downtime, the untimely repairments and the cost of maintaining mobile repair workroom [13]. In studies [14, 15], it is noted that when designing a fleet maintenance system with MRWs, in addition to determining their number it is necessary to select the optimal set of process equipment, its place the workroom and select the vehicle chassis. The proposed methods don’t pay attention to the issues of functional affiliation, operating conditions and the nature of technological operations, their cyclical nature and complexity, although these factors are key in assessing the causes of the failures of machines, their systems, components and assemblies.

The purpose of the research is to develop a technique for selecting mobile repair workrooms and their completeness while eliminating machine failures during reclamation work.

2. Materials and methods
We investigated the flow of failures and the costs of operating units of technological complexes when performing reclamation works of a specialized organization. The technical equipment included standard complexes with the following units: KF-2.8 brush cutter, MP-15 loader collector, BDM-2.5 land-reclamation harrow, BDT-3.0 heavy disk harrow, PV-1.5 wood residues, planner VP-8, skating rink water filling ZKVB-1.5A, seeder APP-2.8. These machines are widely used in the performance of reclamation works.

3. Results and discussion
The experience of repair and technical impacts (RTI) in the elimination of machine failures at land reclamation facilities has shown that the use of several mobile repair workrooms is the most effective. In this case, the MRW is considered as a service department of a land reclamation institution, including personnel performing repair and maintenance impacts, repair and process equipment (RPE), and repair materials [16].

To determine the amount of RTI, we developed a mathematical model that describes the minimum cost of operating units of technological complexes, based on the amount of work done, taking into account the losses from machine downtime due to sudden failures.

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Y(a) = \frac{C_1 M_{0(a)} + C_2 (M - M_{0(a)}) + C_3 S}{MW_0 (1 - K_{n(a)})} \rightarrow \min
\]

where: \(Y(a)\) – minimum cost of operating units of technological complexes, rubles / ha.; \(C_1\) – unit downtime losses, rubles / hour; \(C_2\) – direct costs of operating one unit, rubles / hour; \(C_3\) – the cost of maintaining service posts using MRW, rubles/hour; \(M_{0(a)}\) – average number of inoperative units, pcs.; \((M-M_{0(a)})\) – average number of operating units, pcs.; \(S\) - the number of service posts using MRW, pcs.;
Kn(a) – aggregate downtime factor; Wo – hourly average operational productivity of one technological complex, hectare / ha, M – total number of units, pcs.

For machine complexes that perform reclamation works, we established that, depending on the availability of RTI using MRW, the specific operating costs vary along an extreme curve and have their own optimum (Figure 1).

![Figure 1. The dependence of costs in the operation of units of the technological complex from the availability of repair and technical impact using MRW.](image)

Analysis of the dynamics of changes in cost components shows that the increase in costs for eliminating failures is associated with the attraction of additional service points (MRWs). Increasing the availability of RTI using MRWs leads to a reduction in losses from the downtime of reclamation units for technical reasons. With a minimum availability of RTI, the unit cost of operation is of the greatest importance, which is associated with an increase in losses from the downtime of reclamation units for technical reasons [16]. Analysis of the dependence of costs in the operation of units of technological complex from the availability of RPE shows that there is an optimal amount of RPE when performing repair and technical impacts. Thus, using the proposed model, it is possible to determine the required number (S) of MRWs, taking into account the optimal number of RTI.

However, the effectiveness of repair and technical impacts largely depends on the configuration of the MRW repair and process equipment. The nomenclature of the RTE depends on the list of repairs being carried out and is determined by the structure of the machine failures. Based on the analysis of the flow of failures, it has been established that the elimination of malfunctions of the units of technological complexes for the performance of reclamation works is mainly associated with disassembly-assembly, mounting and adjusting, diagnostic, welding, washing and lubricating works. Therefore, MRWs must be equipped with a disassembly-assembly tool, diagnostic welding and fitting equipment, washing and filling installations.
In general, the equipment of the MRW set with the necessary equipment of i-name (equipment identification) $N_{eq.id}$ is determined as follows:

$$N_{eq.id} = \frac{Q_i}{F_{Wt} m_{sp} K_f},$$

where: $Q_i$ - the complexity of the i-type of work, man-hour (determined on the basis of the analysis of the flow of failures, the standards of troubleshooting labor intensity); $F_{Wt}$ – daily working time fund of MRW, hours; $m_{sp}$ - the number of service personnel (repair technicians) in the repair workroom (excluding mechanics-drivers of repaired cars); $K_f$ - equipment utilization coefficient (takes into account the time spent on the preparation and adjustment of equipment, tools and accessories). Daily fund of working time depends on the duration of the works by repair workroom per day when the reclamation units perform their tasks. To correct the results of calculating the required amount of MRW equipment, it is necessary to take into account the demand for certain types of work provided by certain equipment [17-18]. The specified number of sets of technological equipment is determined by the expression:

$$N_{eq.id}^F = \frac{N_{eq.id}}{K_{dem}},$$

where: $N_{eq.id}^F$ – number of sets of equipment; $K_{dem}$ - demand ratio on the types of work provided by the set. $K_{dem}$ for individual sets of equipment, based on the existing set of mobile repair workrooms, is determined

$$K_{dem} = \frac{F_{Wt}}{\sum F_{Wt}},$$

where: $F_{Wt}$ - daily worktime fund of mobile repair workroom that performs i-th type of work, man-hour, for land reclamation units is accepted, within 6-8 man-hours; $\sum F_{Wt}$ - total daily fund of sets, for performance of i types of work, man-hour.

Based on the proposed methodology for troubleshooting at technological complexes performing reclamation work, we recommend a mobile repair workroom based on a car chassis in the following configuration: lathe, gas welding equipment, automatic welding, sandpaper, drilling machine, crane, oxygen and propane cylinders, synchronous generator, two two-level beds, two household cabinets, a table, two autonomous heaters, an intercom, a mini-kitchen.

Calculations show that the use of MRW on the basis of the Ural 4320-58 chassis as part of the service of the operating organization, while eliminating the failures of machines belonging to the reclamation complexes, will reduce the unit operating costs by 20-30%.

4. Conclusion

1. The failures of equipment in melioration organizations, as a rule, are being repaired on-site by forces of on-site repair teams equipped with mobile repair workrooms (MRW).
2. Cost analysis in the operation of units of the technological complex shows that there is an optimal amount of MRWs when performing repair and technical impacts.
3. A technique has been developed to select mobile repair workrooms and their completeness with repair and technological equipment while eliminating machine failures during reclamation work.
4. To eliminate machine failures when performing reclamation works as part of the service department of the Federal State Budgetary Enterprise “Spetsmeliovodkhoz” management”, it is recommended to use a mobile repair workroom based on the chassis Ural 4320-58.
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