Efficiency Increase of Sowing Complexes

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Abstract. The sowing combined machine-tractor units and complexes have a great potential for productivity. However, in practice, the potential implementation remains at the level of 45-55%. The reason for this is the low reliability of agricultural machines that are part of the units. At the same time, the high cost of complexes causes it to belong to large agricultural associations and holdings that have significant acreage and correspondingly long distances to repair and maintenance facilities. In this case, the task of ensuring the required level of reliability of sowing complexes can be successfully solved by mobile service units. To do this, it is necessary to determine the causes of downtime of sowing units and complexes and set the optimal values for the parameters of the processes of using the units and restoring its operability. The reasons for downtime of aggregates were established by time-based monitoring in several agricultural holdings in the Chelyabinsk region. The controlled seed aggregates and complexes were divided into three groups according to the degree of realization of its productivity potential. For each group of units, the qualitative and quantitative parameters of spare parts stocks of agricultural machines were determined; modes of operation of mobile units for maintenance and repair of crop complexes, elimination of its malfunctions and breakdowns, assistance to drivers of units in eliminating the consequences of failures. The measures are proposed to reduce downtime of sowing complexes for organizational and other reasons. This made it possible to increase the degree of realization of the potential of sowing units and complexes.

1. Introduction

The potential productivity of combined machine-tractor units (MTU) is 150-200 ha/day at two-shift work, and its seasonal production is in the range of 2-3 thousand hectares of crops in one complex [1–2]. Due to technical and technological failures, most often agricultural machinery aggregates, the coefficient of use of working time by the sowing complex (SC) does not exceed 0.45...0.55 [3–4].

The operational reliability of modern tractors, including imported ones, is relatively high. Their operating time for failure of the II and III groups of complexity is 300-600 hours [5–6]. At the same time, failures of working machines in complexes occur in an order of magnitude more often, its time to failure is, on average, 15-25 hours [7–8]. Despite the low complexity of eliminating the consequences of failures of agricultural machines (within 0.5...1.5 people/h), the frequency of its occurrence and, most importantly, the waiting for the machine component part (MCP) or exchange node to restore the SC performance [9] determine the long downtime of complexes.

It is obvious that the implementation of potential possibilities of modern sowing combined units requires organizations farms agricultural holdings functioning of the processes of recovery of unit mobile units [10–14]. The combination of the necessary equipment and materials, the working capital of spare parts and exchange units, the required nomenclature for eliminating the consequences of failures...
of machines and aggregates will allow the staff of locksmiths, using mobile repair shops (MRS-A), to restore the operability of mechanized complexes in a timely manner.

At the same time there is a problem of establishing indicators of the use of imported and domestic sowing combined aggregates in the conditions of the southern Urals and Western Siberia during the spring cycle of field work [15–17].

To solve the problem, it is important:
- to identify the main causes of in-shift downtime of combined sowing units during the implementation of the sowing cycle of grain crops;
- to identify ways to improve the processes of using and ensuring the performance of combined sowing units.

2. Materials and methods

The timing observations over sowing combined aggregates in accordance with the developed technique of experimental researches were conducted in farms of OOO «Agro-Sitno» (Agapovsky region), OOO «Burannoe» (Burannoe village), OAO «Uralskoe» (Nagaybasky region, Gumbeysky village), OOO «Znamenskoe» (Fershampenuaz village), OAO «Balkans» (Balkans village), OOO «OstrolenSkoe» (OstrolenSkoe village), OOO «Kasselskoe» (Kasselskoe village), OAO «Polotsky» (Kizil’skiy region, Polotskoe village), OOO «The Way of October» (Way of October village). The farms are located in the southern part of the Chelyabinsk region. The observations were used to determine the coefficient of use of the working time of a shift (day) of sowing complexes.

For the period of time-keeping observations in the spring cycle of work on farms, 30 combined units were used. Depending on the name, composition and year of production, the combined units were divided into three groups (Table 1).

| Group | Unit name | Qty |
|-------|-----------|-----|
| 1     | K-700A+5C3TC-2,1 | 19  |
|       | K-701+5C3TC-2,1   |     |
| 2     | K-744P1+5CKII-2,1 | 6   |
|       | CASE315+Maxim II  |     |
| 3     | CASE310+Morris Concept 2000 | 5   |
|       | CASE530+Morris Concept 2000 |     |

The main norm-forming factor is the use of shift time (days) and the sowing period [18–19]. To assess the level of utilization of the potential of combined structurally complex, high-speed technological machines in complexes, this method is quite accessible and does not require complex equipment.

To substantiate the technical norm by means of time-based observations, an observer was located next to the machine operator in the cab of the tractor, who had a tablet with a chronocar and a watch. During the day, depending on the number of shifts, monitoring of the unit was carried out, working hours were recorded, time for turns and crossings, to eliminate the consequences of failures, etc. [20–22]. At the end of the shift, the observer measured the fuel in order to determine its consumption, as well as compiled a summary of observations for the day.

During the observations, the timekeeper was constantly near the unit and entered all the elements of the shift time in the order of its sequence from the moment the performers arrived at its workplace in the observation sheet (chronocar). It recorded the reason for each stop and indicates whether the engine was running or stopped [23].
First of all, the timekeeper recorded the start time of the shift in the chrono card. Then he/she filled out the main form of the card, i.e. indicated the elements of working time, current time, and so on.

Recording in the observation list was stopped only when the last operation was completed or the unit was idle at the end of the shift. Before the beginning or at the end of the shift, all additional columns of the observation sheet were filled in, i.e., unit indicators for the shift, and then for the day.

The observation sheet indicated the name of the machines in the unit, its number, brand and design width of the unit. The actual width of the unit, the sowing rate, and the sowing depth are measured by the machine operator. Moreover, the rate of sowing, the depth of sowing timekeeper checked three times per shift, then recorded in the column of the observation sheet average, and at the end of the shift made a reconciliation with the indicators of the accountant and agronomist.

To measure the width of the unit's grip we measured the width of the treated area for 10 passes of the unit and took the average width value.

The information about the characteristics of the site was recorded according to the data of the agronomist and clarified by the observer on the spot. The processed area measurement during the shift was given, indicating its main dimensions. The actual production was determined by the timekeeper together with the accountant by measuring the processed area, as well as by the order sheets, pick-up lists.

The processed data of all chrono cards were entered in a summary table and the average values were determined. Then these indicators were carefully analyzed, as a result of which the appropriate conclusions were determined about the productivity of the unit, the shift rate of production.

The analysis of the unit summary sheet for a single day allowed us to evaluate the unit's performance, specific reasons for downtime, actual performance, and so on.

### 3. Results

On average during the sowing period the main downtime for the first group of sowing units consisted of the time spent on:

- maintenance (79 minutes);
- filling with grain (67 minutes);
- meal (44 minutes);
- work on the paddock (54 minutes);
- unit movement to the field (10 minutes);
- unit turns (8.25 minutes)
- downtime due to technical failures (148 minutes);
- downtime for organizational reasons (81.5 per minute).

The percentage distribution of the main causes of downtime is shown in the diagram (Figure 1).
Figure 1. Time change structure of sowing combined units of the first group.

As you can see from figure 1, only 29% of the time was working time, 21% of the shift time was downtime due to technical failures; 11% - downtime for organizational reasons; 9% - loading the unit with seeds; 7% - the duration of the unit's operation in the paddock; 4% - unit turns; 3% - meal of the machine operator.

The results of statistical processing show that the level of use of sowing combined aggregates of the first group is not high and is at the level of 0.29. In fact, 71% of the shift combined units are idle.

The summary performance indicators of combined sowing units of the second and third groups are shown in Figures 2 and 3.

Figure 2. Time change structure of sowing combined units of the second group.
As can be seen from Figures 1-3, the largest share of downtime occurred for organizational reasons, namely, the timely delivery of machine components to eliminate the consequences of failures of sowing combined units.

Also, the significant downtime of the third group of aggregates (Figure 3) occurred due to the untreated field from the straw of the previous crop, which resulted in 8% of the total time of use of the sowing complex.

The analysis showed that the largest share of technical failures occurs in agricultural machinery: paw, rack, Coulter screen, Coulter diffuser, Coulter shield, high-pressure sleeves, spacer sleeve, seed lines front and middle, etc. The technical failures of sowing machines are caused by the ingress of foreign objects (stones, earth) into it. The duration of tractor downtime associated with repairs (replacement of the cylinder-piston group, replacement of injectors) is explained by the long delivery of spare parts.

4. Conclusion
Analyzing the results obtained we can recommend the following measures to reduce downtime and increase the productivity of combined sowing units:

– to move operations related to technical support and fueling beyond the shift;
– special attention should be paid to restoring the performance of agricultural machines, eliminating failures in the shortest possible time; to do this, organize a mobile link for maintenance and repair of crop complexes, eliminate its malfunctions and breakdowns, and assist machine operators in eliminating the consequences of failures;
– to organize a spare part fund of agricultural machines that most often fail;
– to clear the fields of odd objects.

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