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Organization for repair technology and maintenance of agricultural machinery

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Abstract: ***The article substantiates the need for improving technologies used in repairing and maintaining agricultural machinery. A form was developed for centralizing repair and maintenance activities. The authors highlighted the advantages of the proposed form of optimization for dealerships and agricultural producers. The article's data can be used to plan the expansion of a chain of dealerships in various regions.***

Index Terms**: centralized system of technical services, economic efficiency, technical services.**

I. INTRODUCTION

With agricultural production moving towards market relations, it has become urgent to increase the profitability of agricultural production, cut costs, boost output and increase the quality of agricultural products. Provided that state-of-the-art and more advanced technologies, machinery and production technical bases of agribusinesses are available, it is possible to solve these problems only if major production units and auxiliary divisions clearly adjust methods of organizing output of products, the performance of work and the provision of services.

In the modern economic conditions, it is essential to improve the efficiency of agricultural machinery due to the following factors:

- the technical potential of agribusinesses is in decline;
- prices for machinery and other material and technical resources grow substantially compared with those for agricultural products;
- the high cost of production and mechanized activities; and
- the weak efficiency of production and economic activities carried out by agribusinesses and, as a consequence, the lack of funds for new machinery and high-quality technical services [1] - [3].

The efficiency of modern agricultural production largely depends on timeliness and the quality of mechanized processes and work that, in turn, are sensitive to the availability of machinery and its operability. Taking into account a substantial decline in the fleet of machinery and equipment used in agricultural production, physical depreciation and obsolescence, an urgent problem of implementation of innovation development and technological upgrade at enterprises and divisions within the system of technical services at all levels has emerged.

This cannot be done without reckoning that the rights of agribusinesses – primary consumers of agricultural machinery – are a priority and all the country's manufacturing sectors should be involved. The rights of agribusinesses as a consumer of agricultural machinery should be prioritized by enabling them to buy high-quality and reliable machinery and equipment that fit the level of foreign makes. As international experience shows, it is possible to manufacture high-quality machinery only if proper maintenance is arranged with the direct involvement of machinery manufacturers.

Highly efficient use of advanced high-performance Russian and foreign machinery for designated purposes requires measures to keep it operational throughout the whole period of operation. These challenges are currently faced by engineering and technical divisions of agricultural producers.

In the new economic conditions and provided that agribusiness rights are prioritized, the agricultural machinery and equipment repair and maintenance system requires innovation, organizational and technological upgrade. At the current development level of machinery and equipment maintenance services, it has become more reasonable to substantiate and assess the efficiency range for technical services, the feasibility of repairing parts, units and sets, to distribute activities and the scope of repair and maintenance activities among enterprises that are responsible for them.

The efficiency of technical services is determined by the technical condition and the quality of the machinery and equipment, their indicators of reliability and performance and the level of technical use. All this should be underlined by targeted activities of advanced engineering technical services [4].

II. PROPOSED METHODOLOGY

A. General description

While compiling the article, we used a set of methods and techniques, including review of economic publications on methodology and methods of research related to issues of economic centralization,

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and analytical, abstract logical, statistical economical, calculation constructive and economic-mathematical methods. When studying problems related to the centralization of technical services as a way of improving their economic efficiency, we applied the logical approach based on mathematical modeling.

B. Algorithm

The study of technical provision and organization of maintenance services in the Saratov region allows us to say that activities carried out by regional dealerships need to be improved.

Over the past five years, the fleet of machinery and tractors has declined considerably. As a result, aggregate horsepower provision per unit of cultivated area decreased to 1.2 horsepower per hectare against 3 horsepower per hectare, the utilization rate of available machinery increased and, as a consequence, the breakdown rate of machinery grew. Agribusinesses in the Saratov region are currently supplied by 40-50% with machinery. A reduction in the number of machinery to be provided to agribusinesses was driven by the imbalance in the number of machinery commissioned and put out of operation due to depreciation and obsolescence. The tractor fleet's annual renewal ratio is below the target (10-12%), and it is viewed as a major restraint for a technical and technological upgrade in the agricultural sector.

So, the compliance with agrotechnical deadlines for agricultural production in the course of energy-intensive fieldwork, to a large extent, depends on service providers that should react to machinery failures as fast as possible and eliminate them properly. Agricultural machinery is maintained and repaired by mobile teams. The Saratov region has a big territory, as a result of which service providers have to sustain higher transportation costs, agricultural machinery remains idle and, as a consequence, the efficiency of the region's agricultural sector decreases.

Agribusinesses are currently serviced in accordance with the approved division of the region's territory into four service zones, while the dealership's head office and mobile repair and maintenance teams are based in the region's center (Saratov, Fig. 1).

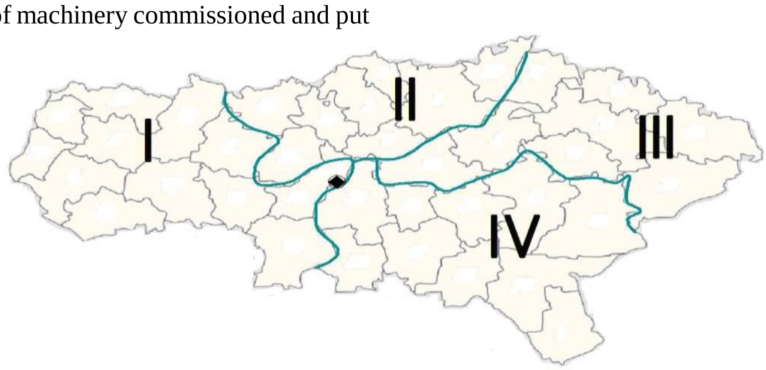

Fig. 1. Division of the Saratov region's territory into service zones

This division helps reduce the wait time for units and spare parts, improves the efficiency of maintenance and repair. However, such a division is not optimum due to unequal distribution of major agricultural producers and their facilities in the region's territory.

The concentration of dealership units in the regional capital is explained by large distances that mobile teams have to cover to service machinery located all across the region, thus increasing the time required for repairs and adversely affecting the compliance with agrotechnical deadlines during energy intensive fieldwork. The total distance among all agricultural companies in the Saratov region is equal to 6,246 km [5].

In the conditions when districts are located far from regional capitals, like the Saratov region, the above drawbacks can be eliminated by centralizing a network of repair and maintenance units that are located in the territory under service. The regional capital will retain a dealership's repair facility and managers of the services unit, while mobile repair teams will be attached to repair and maintenance divisions which are located in accordance with the annual average number of maintenance and repair sessions.

The positive effect from centralization is shown in Fig. 2. When the system is decentralized, all repair and maintenance orders end up in a long line. A new order placed into the system is added to a shorter line (Fig. 2, a). However, there is no information about the condition of the service channel or the scope of work required in earlier placed orders. All this leads to longer periods of standstill in anticipation of repair and maintenance.

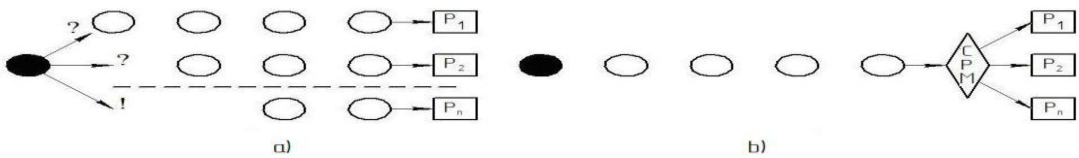

Fig. 2. Scheme shows how orders are processed when management systems are decentralized (a) and centralized (b)

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In case of a centralized system, all orders form a queue (Fig. 2, b). Orders are distributed by the Center of Production Management (CPM) that eliminates the above-mentioned drawbacks [6].

Once the operation of dealerships' repair maintenance units gets centralized, it takes much less work, time and funds to keep agricultural machinery operational.

The optimum number of units to repair and maintain agricultural machinery is determined by means of mathematical modeling under the following formula:

$$\sum_{s=1}^{T}\left(\omega_c^s\theta - Y\Delta t_s Z\sum_{l=1}^{K} m_l\right) = 0,$$

where ω_c^s is the intensity of incoming repair and maintenance orders; θ stands for average labor intensiveness of a maintenance order; Y is the labor productivity of mobile repair teams; Z stands for the utilization rate at repair maintenance shops (RMS); m_l is the number of teams l; K is the number of machinery RMS [7].

The model is based on the comparison of an incoming flow of repair maintenance orders and the number of repair maintenance actions that the technical services system can take.

The optimum number of shops to repair and maintain agricultural machinery was determined based on data of an incoming flow of repair maintenance orders during the period of time under review (twelve months, in this case) by months, with the subsequent definition of intensity of an incoming flow of maintenance orders per day. Daily labor intensity of activities was calculated based on the intensity of an incoming flow of repair maintenance orders and average labor intensity θ of 5.22 man-hour. Table 1 shows a portion of the period of time under review, during which a queue tends to appear in the system, consisting of 1, 2 and 3 shops for repairing and maintaining agricultural machinery.

Table 1. Interpolation of the incoming flow of repair maintenance orders

Days of the year	Incoming flow of orders per month	Intensiveness of orders per day	Daily labor intensity, man-hour	Working hours, 1 RMS, hour	Working hours, 2 RMSs, hour	Working hours, 3 RMSs, hour	Working hours, 4 RMSs, hour	Queue for 1 RMS, hour	Queue for 2 RMS, hour	Queue for 3 RMS, hour
197	141	5	24	8	16	24	32	880	131	
198	142	5	24	8	16	24	32	896	139	
199	143	5	24	8	16	24	32	913	147	1
200	144	5	24	8	16	24	32	930	156	2
201	145	5	24	8	16	24	32	947	164	3
202	145	5	24	8	16	24	32	964	172	4
203	146	5	25	8	16	24	32	981	181	5
204	146	5	25	8	16	24	32	998	190	6
205	147	5	25	8	16	24	32	1,015	198	7
206	147	5	25	8	16	24	32	1,032	207	8
207	147	5	25	8	16	24	32	1,049	216	9
208	147	5	25	8	16	24	32	1,066	225	10
209	147	5	25	8	16	24	32	1,083	233	11
210	147	5	25	8	16	24	32	1,100	242	12
211	146	5	25	8	16	24	32	1,117	251	13
212	146	5	25	8	16	24	32	1,134	259	14
213	143	5	24	8	16	24	32	1,151	267	15
214	140	5	24	8	16	24	32	1,167	275	15
215	137	4	23	8	16	24	32	1,183	282	15

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216	134	4	23	8	16	24	32	1,198	289	14
217	132	4	22	8	16	24	32	1,213	295	13
218	129	4	22	8	16	24	32	1,227	301	11
219	126	4	21	8	16	24	32	1,241	306	9
220	124	4	21	8	16	24	32	1,254	311	6
221	121	4	20	8	16	24	32	1,267	315	3
222	119	4	20	8	16	24	32	1,280	319	
223	117	4	20	8	16	24	32	1,292	323	

III. RESULT ANALYSIS

Here's the comparative analysis of total costs incurred to execute repair maintenance orders in the queue and the amount of investment in the various number of RMS for agricultural machinery. Losses suffered by agricultural producers due to idle time of machinery are calculated at the cost of 1 man-hour of service activities that equals USD 21.00, while it costs around USD 36,842.00 to run one RMS (Fig.3).

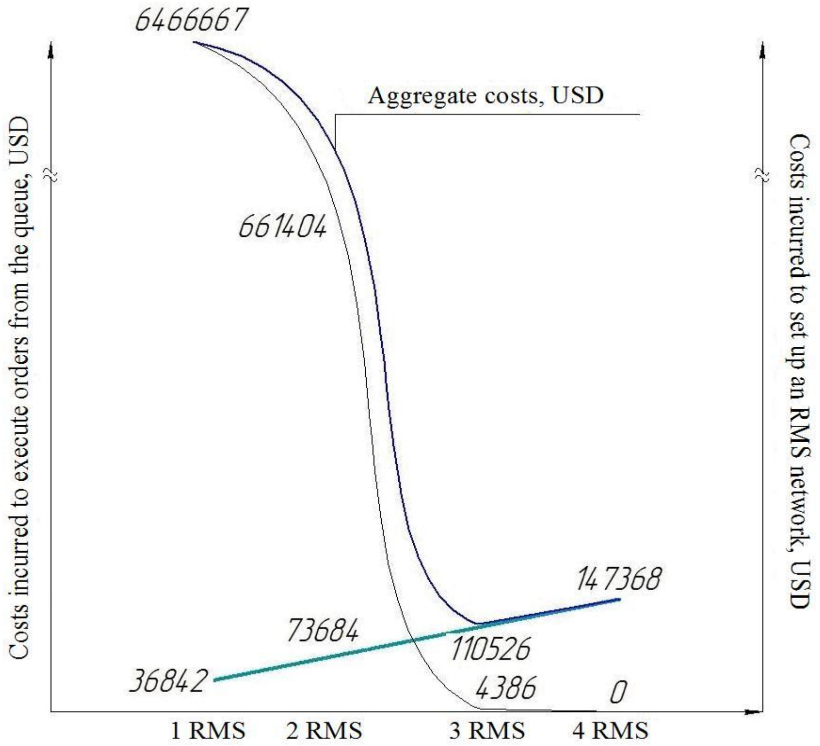

Fig. 3. Comparative analysis of costs to establish a chain of RMS for agricultural machinery and costs to execute orders from the queue

Fig. 3 clearly shows that 3 RMS also constitute an optimum option to centralize technical services.

The location of RMS across the Saratov region is one of the areas for the regional dealership to optimize its maintenance services. The Saratov region boasts of a wide road network.

It is proposed to establish RMS in the districts from which repair maintenance orders come most often, and this will make it possible to do a lot of work fast. The districts were grouped into service zones in accordance with a machinery manufacturer's requirement for the remoteness of a service zone (200 km) [5].

To improve the efficiency of activities of repairing and maintaining machinery, it is proposed to locate RMS as follows (Fig. 4).

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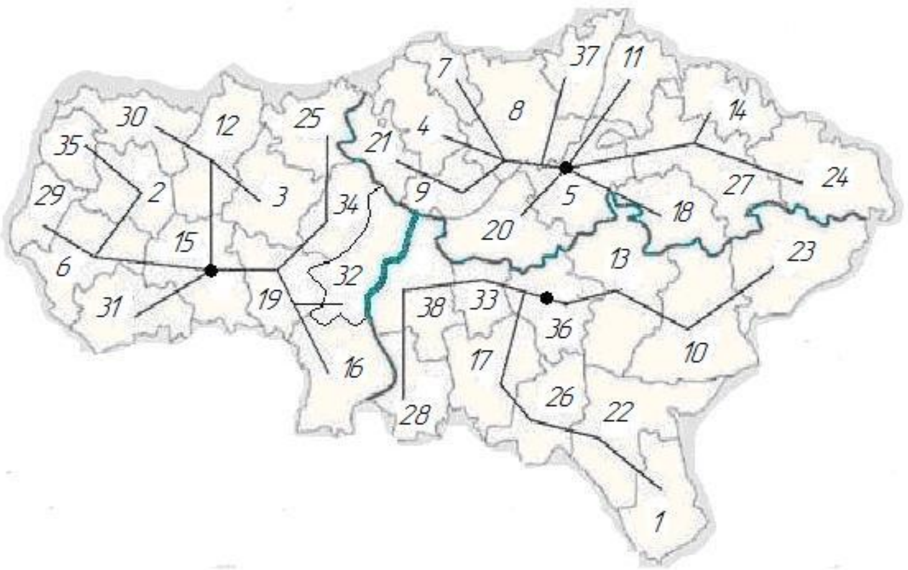

Fig. 4. Location of RMS

The Saratov region is divided into right-bank and left-bank zones. For servicing the right-bank zone, considering its smaller length from north to south and a more compact arrangement of areas, one RMS is sufficient. For the RMS in the western part of the region, the location is suggested in the city of Kalininsk, which is situated in the center of this service area and is one of the leaders in the number of calls to the customer service (Table 2).

The left bank zone is characterized by a greater remoteness of areas from each other. To service the agricultural equipment of this zone, it is proposed to create two RMS. Repair and maintenance of the northern areas is performed by the RMS in the city of Balakovo. The location in the selected city allows to serve equally efficiently the areas of both the right-bank and left-bank zones, as well as to quickly carry out work in the Perelyubskiy district. This area is one of the most remote areas of the Saratov region and is included in the first five areas by the number of calls to the customer service (Table 3).

Table 2. Service areas of the Kalininsk RMS

No. at Fig. 4	District	Remoteness, km	Volume of work per year
15	Kalininskiy	0	29
19	Lysogorskiy	30	12
12	Ekaterinovskiy	67	26
31	Samoylovskiy	82	32
6	Balashovskiy	100	21
32	Saratovskiy	116	29
3	Atkarskiy	117	27
34	Tatischevskiy	117	19
30	Rtischevskiy	125	26
29	Romanovskiy	142	12
2	Arkadakskiy	147	24
16	Krasnoarmeyskiy	158	16
35	Turkovskiy	173	21
25	Petrovskiy	195	43
Total volume of work per year			337

Table 3. Service areas of the Balakovo RMS

No. at Fig. 4	District	Remoteness, km	Volume of work per year
5	Balakovskiy	0	21
8	Volskiy	43	13
37	Khvalynskiy	70	9
18	Krasnopartizanskiy	85	16
27	Pugachovskiy	90	18
11	Dukhovnitskiy	98	9
20	Marksovskiy	105	24
7	Baltayskiy	117	5
4	Bazarnp-Karabulakskiy	120	24
9	Voskresenskiy	125	21
14	Ivanteevskiy	134	39
21	Novoburasskiy	157	12
24	Perelubskiy	206	33
Total volume of work per year			244

The third service zone is serviced by an RMS in the urban-type settlement Mokrous. Indicators of remoteness and annual volume of work are presented in Table 4.

Table 4. Service areas of the Mokrous RMS 252

No. at Fig. 4	District	Remoteness, km	Volume of work per year
36	Fedorovskiy	0	34
13	Ershovskiy	62	59
33	Sovetskiy	66	29
17	Krasnokutskiy	70	30
10	Dergachevskiy	107	19
38	Engelskiy	112	26

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26	Piterskiy	117	13
22	Novouzenskiy	157	8
23	Ozinskiy	177	9
28	Rovenskiy	194	19
1	Algayskiy	211	6
Total volume of work per year			252

IV. DISCUSSION

The location of RMS for agricultural machinery should be chosen in accordance with the requirements for the location of manufacturing buildings and structures, which include:
- close proximity to consumers to offer the shortest wait time;
- the equal utilization rate in service zones to repair and maintain agricultural machinery in the region;
- the location in close proximity to large localities (district centers) and major thoroughfares to avoid problems with required facilities or qualified personnel.

The proposed system for organizing a regional technical service is characterized by a more loaded right-bank RMS and an even distribution of the annual volume of work between the two left-bank RMS. A positive characteristic of this system is the reduction in the number of service zones and crews necessary for their service without prejudice to the implementation of the entire annual volume of work, as well as the reduction in the total remoteness of areas from service enterprises by 33% (from 6246 to 4192 km).

The efficient organization of technical services makes it possible to improve the technical readiness of the tractor fleet due to high-quality repair and maintenance. Economically efficient measures to organize machinery repair lead to weaker demand for spare parts and supplies, the higher operation time of tractors, harvesters, vehicles and agricultural machinery. All this creates conditions to substantially strengthen the material and technical base of the agricultural sector [8].

Organizing technical services in the new economic conditions requires a scientific approach and new forms to provide efficient use of the available material and technical base of agricultural producers [9].

As far as the efficient use of fixed assets at repair shops is concerned, the major factor is the machinery repair time. Shorter repair time reduces the number of vehicles under repair and the space occupied by disassembly and assembly units.

Economic efficiency of enterprises that provide technical services, repair and maintain machinery can be improved by:
- using advanced means of technical service and repair which reduce the duration of repair and labor intensiveness;
- training workers to become more qualified to provide high-quality technical and repair services; and
- forming mobile repair teams to do repairs not only on the premises of an RMS.

To assess economic efficiency of work performed at RMS, we calculated funds to be saved per year owing to the system of organizing technical services in the region compared with the system in use (Table 5).

Table 5. Comparative efficiency of technical service systems

Indicator	Systems used to organize technical services		+/-
	In use	Proposed	
Transport costs incurred by service providers, USD/year	42,105	29,825	12,280
Maintenance of vehicles, USD/year	24,963	18,723	6,240
Wages paid to repair teams, USD/year	40,421	30,316	10,105
Funds saved per year, USD	-	-	28,625

V. CONCLUSIONS

In this study, we an important economic task for the industry, namely shorter idle time for machinery, and lower repair and maintenance costs by centralizing technical services. The purpose of improving the system applied to organize technical services in the region is to enhance economic efficiency and stability of agricultural machinery dealerships. Consequently, the simulated system of organizing technical services in the region contributes to developing service providers in Russia in line with international standards.

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