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Machine-Tractor Aggregates Operation Assurance by Mobile Maintenance Teams

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Abstract: operability of machine-tractor aggregates (MTA) is ensured by purposeful activity of maintenance and repair performers. MTAs' operation assurance can provide achievement of absolutely different goals. For further development of technical service formation concept concretization in the part of determining locations of maintenance and repair performers and their area of expertise is suggested, as well as of arising peculiarities of equipment. The theoretical task is reduced to the type of tasks of distribution of recourses or transportation tasks. Mobile maintenance teams of regional agricultural equipment manufacturers' dealers have experience of technical service performance. The formed stream of requests from agricultural plants determines the direction of correcting of existing theoretical provisions, confirming necessity of further development of centralized method of technical service by efforts and means of manufacturers' dealers.

1. Introduction

Machine-tractor aggregates performance assurance can provide achievement of absolutely different goals determined by the type and composition of the aggregate, crop-growing production plan for the current year, maintenance and repair performer organizational relation, etc.

The most urgent operational goal is to ensure MTA reliability during performance of crop farming tasks. The strategic goal is to ensure MTA functioning during its standard service life.

Graphically the aims can be presented in the following way:
The goal choice can have significant influence on the applied maintenance and repair technologies and consequently on the quantitative and qualitative composition of maintenance and repair performer group.

We described the concept formation [1, 2] of MTA maintenance and repair process organization starting from the definition of basic notions, in the earlier published works [3]. The presented concept of the technical service suggests its further detailing in the part of location of the maintenance and repair performers and their field of expertise as well as arising peculiarities of equipment in disposal.

The technical service department organization structure represents separate maintenance and repair units of MTP in general and MTA in particular divided according to their number, location, equipment, and staffing level.

The regional-district division principle is based not only on the territorial adjacency but also on the similarity of agricultural production directions, adequate structure of MTP, similar staffing level.

Territorial independence is necessary for activity coordination of a designed body with local authorities represented by district administration for agriculture, State Technical Supervision Body inspections.

The structural organization can have several levels:
1 – regional level
2 – district level
3 – inter-farm level
4 – plant level
with formed coordination and subordination connections.

The connections formation can take place as with creation of non-profit partnerships and associations, inter-farm specialized enterprises, as well as with formation of maintenance and repair of complex equipment affiliates by central organizations.

2. Research results
Let us consider the such basic notions as basics of developed concept, in philosophic aspect, as notions representing a model of thinking, "reflecting and fixating important traits of things and phenomena of objective reality". In the structure of the notion the dialectics of singularity, specific and universal finds reflection [4].

In accordance with triality of every notion it is possible to separate three levels of MTA operation assurance:
1-st level - monthly maintenance and maintenance-1 of MTA equipment and tractors.
2-nd level - complex maintenance of units, aggregates and MTA systems - motors, transmission, hydrosystems, electrical equipment, working parts.
3-rd level - periodic general control and instrumental evaluation of technical condition of MTA machines.

The first level can be performed by efforts of mobile maintenance teams of farms or by teams if inter-farm unions, i.e. on the inter-farm level and on the plant level.

The second level can be implemented by the efforts of mobile teams of special regional service and repair organizations, i.e. on inter-farm level.

The third level can be performed by efforts and means of dealers of agricultural equipment manufacturers i.e. on the regional level.

Thus, the task is to distribute the scope of MTA maintenance works between possible technical service providers of different levels.

To ensure MTA operation it is necessary to perform the volume of works $Q_i$ of maintenance of different complexity $x_{ij}$ (see the table) at known price for maintenance services of different level $C_i$.

Known:
- unit cost of crop loss $a_{ij}$ at MTA downtime during performance of technical service of $i$ level,
- index of mobile maintenance teams transportation costs $b_{ij}$.

Table 1. The distribution of the scope of MTA maintenance works between providers.

<table>
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<th>$Q_1$</th>
<th>$Q_2$</th>
<th>$Q_3$</th>
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<td>$C_1$</td>
<td>$x_{11}$</td>
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<tr>
<td></td>
<td>$a_{11}$</td>
<td>$a_{12}$</td>
<td>$a_{13}$</td>
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<tr>
<td>$C_2$</td>
<td>$x_{21}$</td>
<td>$x_{22}$</td>
<td>$x_{23}$</td>
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<td>$a_{21}$</td>
<td>$a_{22}$</td>
<td>$a_{23}$</td>
</tr>
<tr>
<td>$C_3$</td>
<td>$x_{31}$</td>
<td>$x_{32}$</td>
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</table>

The task relates to the group of tasks on distribution of recourses or transportation tasks.

It is necessary to perform the scope of MTA maintenance works having distributed it across the levels of technical service in the following way:

$$Q_{ij} = \sum_{j=1}^{3} x_{ij}, \quad (1)$$

With that the cost of expenses and losses must be minimal:

$$\sum_{i=1}^{3} \sum_{j=1}^{3} C_{ij} x_{ij} a_{ij} b_{ij} \rightarrow \min \quad (2)$$

Over the last years a new form of maintenance of agricultural plants became widespread - mobile maintenance teams that perform works on site. Mobile equipped maintenance teams perform works immediately at fields where tractors and self-propelled vehicles operate. This type of maintenance of MTA stock reveals and eliminates different failures as mobile team experts widely use means of technical diagnostics [5], which in its turn makes it possible to continue work in a short term.

As a rule mobile maintenance teams are formed at dealer centers which assume responsibility on organization and execution of warranty and post-warranty service in the scope and in volume specified by technical documentation [6].

Warranty service and dealer’s maintenance [7] includes:
- providing and canceling equipment warranty registration;
- maintenance, replacement of defective details, equipment failure elimination on machines under warranty.
- instructing and training of farm machinery operators and agriculture experts
- control over following the operation rules by the owner, timely and full maintenance (monthly maintenance, maintenance-1, maintenance-2, conservation/starting after winter downtime);
- on-call consulting and on-site visit of technical center experts in order to eliminate technical problems
- supply control and equipment operation starting after winter downtime
- dealer's service in post-warranty period

Dealers perform a complex of necessary and accompanying measures on equipment maintenance under warranty. The scope and requirements to the service are defined in the "Technical specification and operation manual", Service book, and other instructions accompanying the equipment. [8].

Service center eliminates defects and recovers manufacturer's product during warranty period in the shortest possible time, but no longer than in three days starting from the date of receiving message about equipment failure. Warranty maintenance on manufacturer's recommendation is performed in the following periods [9]:
- if dismantling of main units is not required - during 24 hours;
- if dismantling of main units is required - 48 hours;
- dismantling is required together with replacement of basic details (frames, semi-frames, motor unit, drive axle, change gearbox) within reasonable time agreed with the contractor but no more than 72 hours from the moment of receiving from the manufacturer a message about equipment failure and equipment damage statement[10].


Let's consider the main trends of formation dealer's service in the Omsk region on the example of a dealer. Technical center of the supply base "Sibirskaya" performs not only warranty repair but also post-warranty period maintenance, as well as running repair of equipment purchased in other firms. The personnel accounts 14 people: chief engineers, mechanics, diagnostic personnel, setup technicians, fitters, fitters-electricians. Portative unit of maintenance is equipped with the following tools - diagnostic tools, set of wrenches, compression gauge, conditioning equipment charging tools [11]. Considering the distribution of maintenance requests among the districts of the Omsk region in 2016 (pic.2) one can note quite significant difference of requests frequency from zero to 40 requests for one season. When counting the number of requests to the service center, both types of requests were taken account - as for planned maintenance, and complaints about equipment failure among main customers of the supply base "Sibirskaya".

Data analyses allows for the conclusion that service is more required in districts located closest to Omsk as administrative center which is connected with lower transportation costs. Also maximum number of requests is registered in the districts where the largest agricultural enterprises with high turnover and revenue are located.

Agricultural enterprise where technical service and elimination of current defects (pic.3,4,5) were carried out are situated at different distances from the dealer center. In connection with this a decree was issued according to which tariffs for distance are as follows: up to 100 km in both directions costs 10 rub per 1 km, if the distance is more than 100 km, the tariff is 9 ruble per km.

Pic 2 shows that the farther an agricultural enterprise is from the dealer center the more expensive the warranty service is. In order to perfect the system of technical service it is needed to open additional warranty service points, it will cut losses on mobile maintenance teams servicing which in its turn also will make it possible to perform maintenance at shortest possible time.
Picture 2. - Distribution of requests to the service center of OOO "Sibirskaya" supply base according to the districts of the Omsk region for the year 2016 [12]

Picture 3. - Distribution of requests on Minsk Tractor Plants' tractors maintenance 82, 82.1, 82.2 by mobile teams of OOO "Sibirskaya" base (2014 – 2016) [12]
Picture 4. - Distribution of maintenance requests according to equipment type serviced by mobile maintenance teams of OOO "Sibirskaya" base (2014–2016) [12].

Picture 5. - Distribution of technical service requests for equipment maintenance performed by mobile teams of OOO "Sibirskaya baza" according to months (2014–2016) [12]
3. Conclusions
MTA operability assurance can help to achieve absolutely different aims, the most urgent is to ensure reliability of MTA during execution of current operations on crop growing. The choice of aim can have significant influence on applied maintenance and repair technologies and consequently on qualitative and quantitative composition of maintenance and repair performers. Organizational structure of service center represents regional independent maintenance and repair units of all MTP and MTA in particular.

Over the last years a new form of maintenance of agricultural plants became widespread - mobile maintenance teams that perform works on site of agricultural enterprises. As a rule mobile maintenance teams are formed in technical centers of dealers which undertake the responsibility on organization and performance of warranty period and post-warranty servicing of agricultural machinery in the scope and quality determined by technical documentation. Because of underdevelopment of engineering services in agricultural enterprises mobile maintenance teams also perform other works on servicing, maintenance and elimination of agricultural equipment failures.

Reference