Information System of Machines and Tractors Fleet Technical Service

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Abstract: providing technical services also requires providing quality assurance of these services. Results of leading experts’ research in this field is not always available for engineers of agricultural companies, that is why there is need for development of a customer quality assessment method or a method of quality assurance by technical services suppliers. Project of machines and tractor fleet technical service system which included an assembly of interrelated and interdependent elements – processes running in machines, technologies of technical service, performers of technical service – is defined and directed by the aim of technical service which consists in maintaining operability of agricultural equipment, allows to create a method of quality assessment. The quality index represents multiplication of partial factors which take into consideration degree of correspondence of performed volume of works to the required volume, degree of correspondence of maintenance intervals to the required intervals, degree of conformity of repair and maintenance technologies to processes in subsystems; sufficiency of performers competence for implementation of repair and maintenance; sufficiency of range of works potentially carried out by technical service performers for maintenance of a certain types of machine- and tractor aggregates. The degree of correspondence of intervals can be ensured by meeting the requirements of standards and technical documentation. The volume of technical services works can be provided by involving a group of technical service performers. A variant of technical service performers’ competence assessment method is suggested. Along with that an information system of technical service is developed which allows to state interdependencies determining quality of technical service.

1. Introduction

The problem of the services quality is the most urgent followed by timeliness of their provision. Particularly critical is the situation of machines maintenance including agricultural equipment. Machines and tractors fleet of companies is heterogeneous in composition, technical state, and age. As a rule, companies providing technical service are highly specialized and high quality maintenance of even units of same type of similarly functioning machines manufactured by different companies is not to be expected. Nevertheless, under the conditions of absence of maintenance means and critical shortage of engineering personnel, agricultural companies apply to external companies for technical services. At that point the issue of quality assessment by customers or quality assurance by suppliers becomes urgent and requires solution.

2. Results

Quality of maintenance has become the object of research of many scientists [1]. Most comprehensively the problem was addressed by Solomkin A.P. [2]. He suggested assessing maintenance quality according to assembly of three criteria: accuracy, completeness, timeliness.
The criterion of timeliness relates to complying with standard values of maintenance intervals of different machines units and subsystems. During the period of field works the problem is solved by applying the method of centralized maintenance by a group of experts at availability of time slack and productivity margin [3].

The criterion of completeness relates to the level of performed range of maintenance operations indicated in standards and technical documentation [4]. Ensuring maintenance completeness is also provided by applying the method of centralized maintenance by a group of experts with distribution of maintenance tasks among several performers in order to complete the whole range of maintenance tasks in the course of the short period of the machines standby during field works [5].

The criterion of accuracy is the most complex one as it cannot be estimated only by defining availability and comfortability of performing this or that maintenance operation. Undoubtedly, construction of agricultural machines influences the maintenance accuracy, but the accuracy estimation would be deficient if the maintenance performers and applied maintenance technologies are not taken into consideration [6].

2.1 Conceptual project of the technical service system

The known conceptual project of technical service system of machines and tractors fleet (MTF) includes an assembly of its interrelated and interdependent elements, which are processes that run in agricultural machines, technologies of technical service, and performers of technical service, defined and determined by the aim of technical service, namely - maintaining working order of agricultural machines (figure 1) [7].

![Image of interrelations in the system of MTF technical service](image_url)

The aim of technical service comes down to maintaining such value of utilization factor at which needed productivity of MTF is provided:

\[ W_n = W_h K_{uf} \]  \hspace{1cm} (1)

where \( W_n \) – MTF production rate per hour, ha/h;
$K_{uf}$ – utilization factor.

$$K_{uf} \geq K_{uf}^{\text{req}} = K_{uf}^b K_{\mu}$$  \hspace{1cm} (2)

Here $K_{uf}^{\text{req}} = 0.75$ - is basic value of utilization factor,

$K_{\mu}$ - technical service quality factor determined by the dependence

$$K_{\mu} = \prod_{i=1}^{n} \mu_i ,$$  \hspace{1cm} (3)

at $i = 1$–5.

Here

$\mu_1$ – degree of correspondence of performed volume of works to required volume;

$\mu_2$ – degree of correspondence of maintenance intervals to the required number;

$\mu_3$ – conformance of repair and maintenance technologies to processes running in subsystems;

$\mu_4$ – sufficiency of performers competence level for implementing repair and maintenance technologies

$\mu_5$ – sufficiency of the range of works potentially carried out by technical service performers for maintenance of certain type of MTF

The required volume of works is found out by formula

$$W_{TC} = \sum_{k,l=1}^{K,L} A_k MA_k S_l \tau_l ,$$  \hspace{1cm} (4)

where $A_k$ – aggregates under maintenance, $k = 1$…$K$;

$MA_k$ – number of machines in every $k$ aggregate;

$S_l$ – number of subsystems (units, assemblies) in machine $l = 1$…$L$;

$\tau_l$ – maintenance duration of every $l$ subsystem (unit, assembly).

The volume of works carried out by a group of repair and maintenance performers must correspond to required volume of works during technical service of aggregates’ machines:

$$\mu_3 \sum_{i=1}^{N} N_i k_{N} t \geq \sum_{k,l=1}^{K,L} A_k MA_k S_l \tau_l ,$$  \hspace{1cm} (5)

$t$ – maintenance duration, hour

$k_{N}$ – adjustment factor that considers reduction of maintenance duration in case of a group of repair and maintenance performers operation.

Applied repair and maintenance technologies must correspond to processes that run in subsystems (units, assemblies) of aggregates’ machines:

$$\mu_3 \{ \sum_{j=1}^{M} TX_{j} \} \equiv b \{ \sum_{k,l=1}^{K,L} A_k MA_k S_l \}$$  \hspace{1cm} (6)

where $b$ - is proportionality factor which considers degree of similarity of repair and maintenance technologies of different aggregates’ machines

$TX_{j}$ – a $j$ technology from the common range of repair and maintenance technologies из, $j = 1$…$M$.

The range of works carried out by a group of repair and maintenance performers during provision of technical service is defined by:
\[ V_{T.C.} = \sum_{i=1}^{N} N_i K_i \]  

(7)

\( N_i \) – \( i \)-th repair and maintenance performer
\( K_i \) – \( i \)-performer’s competence

And performers competence must be sufficient for implementation of repair and maintenance technologies

\[ \mu_3 \{ \sum_{i=1}^{N} N_i K_i \} \approx \{ \sum_{j=1}^{M} TX_j \} \]

(8)

The range of works carried out by technical service performers must be sufficient for maintenance of certain type of MTF

\[ \mu_3 \sum_{i=1}^{N} N_i K_i > \sum_{k,l=1}^{K,L} A_{k} A_{l} S_{il} \]

(9)

As is evident from our suggestions, accuracy of maintenance is defined by multiplication of factors \( \mu_3, \mu_4, \mu_5 \)

The considered draft of the technical service system is a sufficient methodological ground for generating a maintenance quality factor and for development of system of measures for quality assurance [8-10]. However, estimation of technical service performers’ competence can be deficient because of ignoring the potential of available in the present information technologies.

2.2 Information system of technical service

Taking into consideration recommendations [11] the conceptual project of technical service can be presented in a modified form as a functioning information system of technical service (figure 2).

![Image](image.png)

Figure 2. Information system of technical service

Volume of information contained in the data bases of technical service is defined by the following formula:

\[ \sum I = \sum_{q=1}^{Q} DB_q \]  

(10)
DB₉ – q data base from the list of available data bases:
DB₁ – spare parts catalogs
DB₂ – machines repair and maintenance chart flowsheet
DB₃ – repair and maintenance time standard
DB₄ – repair and maintenance roadmaps
DB₅ – lists of machines under maintenance
DB₆ – ready expert systems on machines diagnosing and malfunctions detection developed by manufacturing plants
DB₇ – users’ open expert systems
DB₈ – systems of machines technical state remote monitoring
DB₉ – catalogs and lists of equipment for performing diagnosing, repair and maintenance
DB₁₀ – list of actually carried out repair and maintenance works aimed at eliminating equipment failures consequences

The list is open and can be filled and widened with development of information technologies.

The main element of information system of technical service are technical service experts. The elements of the information system of technical service are interdependent in the following way:

Performers' competence define the range of implemented repair and maintenance technologies

$$\sum_{j=1}^{M} TX_j = f_1(\sum_{i=1}^{N} N_i K_i)$$ (11)

Implemented repair and maintenance technologies define the choice of aggregates’ machines under service:

$$\sum_{k,l=1}^{K,L} A_k MA_k S_l = f_2(\sum_{j=1}^{M} TX_j)$$ (12)

Machines under service influence the data bases filling:

$$\sum_{q=1}^{Q} DB_q = f_3(\sum_{k,l=1}^{K,L} A_k MA_k S_l)$$ (13)

The technical service data bases filling determines prospective range of technical service tasks:

$$\sum_{p=1}^{P} TST_p = f_4(\sum_{q=1}^{Q} DB_q)$$ (14)

where TSTₚ – are technical service tasks and can be expressed in terms of the range of works necessary for aggregates' machines operability maintenance and recovery.

The list of technical service tasks influences formation of technical service experts’ competence

$$\sum_{i=1}^{N} N_i K_i = f_5(\sum_{p=1}^{P} TST_p)$$ (15)

In its turn, the performers’ competence influences the choice of machines for servicing:

$$\sum_{k,l=1}^{K,L} A_k MA_k S_l = \phi_i(\sum_{i=1}^{N} N_i K_i)$$ (16)

The composition of machines and tractors fleet has significant influence on the range of tasks solved by technical service
\[ \sum_{p=1}^{p} TST_p = \varphi_2 \left\{ \sum_{k,l} A_k M \varphi S_l \right\} \tag{17} \]

Tasks of technical service that are necessary to be solved determine the choice of repair and maintenance technologies:

\[ \sum_{j=1}^{M} TX_j = \varphi_3 \left\{ \sum_{p=1}^{P} TST_p \right\} \tag{18} \]

In the course of implementation of repair and maintenance technologies new information appears for filling technical service data bases:

\[ \sum_{q=1}^{Q} DB_q = \varphi_4 \left\{ \sum_{j=1}^{M} TX_j \right\} \tag{19} \]

Technical service data bases increase the level of competence of technical service experts:

\[ \sum_{i=1}^{N} N_i K_i = \varphi_5 \left\{ \sum_{q=1}^{Q} DB_q \right\} \tag{20} \]

Thus, functioning of the information system of the technical service can be described by the following system of equations:
\[
\sum_{j=1}^{M} TX_j = f_1(\sum_{i=1}^{N} N_iK_i)
\]
\[
\sum_{k,l=1}^{KL} A_{k}MA_{k}S_{k} = f_2(\sum_{j=1}^{M} TX_j)
\]
\[
\sum_{j=1}^{N} DB_j = f_3(\sum_{k,l=1}^{KL} A_{k}MA_{k}S_{k})
\]
\[
\sum_{p=1}^{P} TST_p = f_4(\sum_{j=1}^{N} DB_j)
\]
\[
\sum_{i=1}^{N} N_iK_i = f_5(\sum_{p=1}^{P} TST_p)
\]
\[
\sum_{k,l=1}^{KL} A_{k}MA_{k}S_{k} = \varphi_3(\sum_{i=1}^{N} N_iK_i)
\]
\[
\sum_{p=1}^{P} TST_p = \varphi_2(\sum_{k,l=1}^{KL} A_{k}MA_{k}S_{k})
\]
\[
\sum_{j=1}^{M} TX_j = \varphi_4(\sum_{p=1}^{P} TST_p)
\]
\[
\sum_{j=1}^{N} DB_j = \varphi_5(\sum_{j=1}^{M} TX_j)
\]
\[
\sum_{i=1}^{N} N_iK_i = \varphi_5(\sum_{j=1}^{N} DB_j)
\]

(21)

3. Conclusions
The suggested analytical description of the information system of technical service allows to assess the whole spectrum of technical service quality assurance problems. Competence of technical service experts which is the main element of the system depend from tasks of technical service, but they significantly widened and developed in the course of technical service data bases filling. The data bases filling in its turn takes place under condition of the technical service system functioning. The more intensive the functioning is, the more intensive is the data bases filling.

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