PROSPECTS FOR THE DEVELOPMENT OF IMPORTED FOREST MACHINES MAINTENANCE IN THE RUSSIAN FEDERATION

ПЕРСПЕКТИВЫ РАЗВИТИЯ ТЕХНИЧЕСКОГО СЕРВИСА ЗАРУБЕЖНОЙ ЛЕСОЗАГОТОВИТЕЛЬНОЙ ТЕХНИКИ В РОССИИ

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Abstract: *The article considers the issues of imported forest machines maintenance technology and knowledge management in the North-West of the Russian Federation. The paper proposes a structure of technological instruction to restore parts by welding and building up. Basic requirements for the work-site arrangement are formulated. Theoretical statements are accompanied by calculated reliability assessment of forest machines. The assessment is based on the research of details durability of forest machinery John Deere 1010 and 1410. The research was carried out for four years and included 16 forest machines. The main objects of the research were details of processing equipment (manipulator), hydraulic system, and engine fuel system of forwarder John Deere 1010 D. The efficiency criteria of multicomponent reserve delivery of spare parts and consumables are formulated.*

***KEYWORDS**: MAINTENANCE PERFORMANCE, REPAIR INSTRUCTIONS, SPARE PARTS SUPPLY*

1. Introduction

Development of maintenance management of imported forest machines (FM) operating in Russia, can be considered at the general management level and at the unit level of a maintenance enterprise (Shilovsky, 2001, 2005, 2012).

Maintenance performance policy of forest machines manufacturers is one of the effective tools for expanding the market, because every consumer is interested in cost-effective operation of the purchased equipment. Manufacturers expand the market of their machinery sales and also receive additional income from organizing corporate maintenance. Sometimes this income exceeds the income from the sale of machinery. Corporate maintenance of machinery, i.e. on-site maintenance and repair of equipment, organized by the manufacturer, has an advantage over the organization of repair and maintenance of machines by independent dealer services and requires development and perfection. Corporate maintenance and repair can establish a direct link between the consumer and the manufacturer; help to get information about the machines reliability, the causes of failures as the fault of the manufacturer and the consumer, and to take quick measures to eliminate them. Therefore the main issue is to develop and implement technological instructions to eliminate the failures occurred. The most valuable part of these instructions should be the technology of the failed FM parts, units and aggregates repair, which can be competently developed only by the manufacturer.

The need for such technical documents certainly exists. Consumers and organizations involved in machines and equipment repairing are extremely interested in their speedy development. There are cases when for the elimination of cracks which appeared in the processing FM equipment, the consumer is forced to turn to specialized services to perform chemical analysis of the failed metal construction material to conduct effective welding of cracks with the right electrodes and in the right mode [1, 5].

Indeed, the manufacturer gets more profit selling a greater number of spare parts, even if they can be effectively repaired by the consumer or by specialized repair enterprises. But on the competitive market it is the manufacturer who provides more cost-effective technical operation of the equipment purchased by the consumer who wins eventually.

It is believed that the overhaul of machinery and components is not beneficial for the consumer. This depends on the remanufactured components life time and repair costs. The calculations applied to agricultural machinery show that if the cost of repair is not more than 80% of the cost of the new object, with the full recovery of the component, the repair is beneficial to the consumer.

Repair cost depends on the amount of repair production, if it grows then the price decreases. General strategic maintenance management team has to make preliminary estimates of the repair production volume and the cost of a repaired equipment unit and to suggest an optimal variant of repair volume and the cost of repaired equipment.

One of the examples of the strategic management team’s efforts can be a standard technological instruction of parts’ operable state restoration, which can serve as the basis for an operating technological instruction of specific details restoration. A standard instruction presents a list of regulations which are specified in operating instructions. For example, a technological instruction of parts restoration by welding and welding with flux-cored wires includes:

I. General regulations and a description of the process;
II. The materials used;
III. The influence of welding parameters on the configuration of the weld;
IV. Preparation of welded joints;
V. Choice of welding and surfacing;
VI. Features of a semi-automatic welding;
VII. The equipment for welding and surfacing;
VIII. The organization of the workplace;
IX. Defects and quality control of welded joints;
X. Safety;
XI. Fire-prevention measures.

Section "Workplace" plays a special role in technological instructions. Workplace organization is carried out in accordance with the working draft of a workplace, developed on the basis of the provisions of standard project workplace requirements for all types of jobs. The working draft specifies general positions of a standard project for a specific workplace. A standard project of a workplace includes:

I. General. Main rules of the workplace;
II. Methods and techniques;
III. Maintenance organization;
IV. Means for communication between a workplace and maintenance services;
V. Working conditions (lighting, sanitary requirements, aesthetic requirements, work and rest schedule);
VI. Combining of professions, team form of labor organization.

For example, a working draft of a welder’s workplace (manual arc welding) defines:
• The purpose and plan of the workplace;
• The layout of workspace;

- The map of a welder's work organization;
- The machine-tool attachments;
- Technical and technological documentation;
- Health and safety requirements.

2. Data and Methods

A FM reliability assessment is an important issue for the maintenance service organization. Studies have been conducted to evaluate the durability indicators of FM parts «John Deere» series 1010 and 1410. Research methods included data collection in three main areas:
- Initial Data Collection on failures of parts and components;
- Initial Data Collection on the actual consumption of spare parts;
- Information Collection on the frequency of forwarders maintenance.

The research objects were the parts and operational materials (OM) of forwarders «John Deere», series 1010 and 1410. Initial Data Collection was carried out on timber enterprises of the Republic of Karelia: JSC "Ledmozersky LZH", JSC "Volomsky" and ZAO "Shuyales" in cooperation with the official dealer of «John Deere» in the Republic of Karelia "Petro John Deere Forestry" [2]. The research was carried out for 4 years and included 16 Forest Machines. The main objects of research were parts of technological equipment (a manipulator), hydraulic systems, fuel equipment of forwarder «John Deere» 1010 D. Selection of objects of research (parts) was based on the Unification between FM «John Deere» Series 1010 and 1410.

3. Results and discussion

The results of failures data processing and durability indicators of forwarders parts obtained using known statistical methods are shown in Table 1 (Salivonik, 2006).

Table 1. The results of failures data processing and durability indicators

Part code in the catalog (title)	Indicators of durability for recorded failures / by the actual consumption of spare parts			
	Type of the distribution law	L_{cp}	σ_l	V
F058748 – manipulator shackle	<u>normal</u> log-normal	<u>2164</u> 2314	<u>549</u> 1231	<u>0.254</u> 0.532
RE518088 – High pressure fuel pump	<u>Weibull</u> Weibull	<u>2691</u> 2972	<u>794</u> 1248	<u>0.295</u> 0.420
F064910 – High pressure hose to the rotation of the rotor gripper	<u>normal</u> normal	<u>496</u> 568	<u>198</u> 119	<u>0.398</u> 0.210
F06520 – High pressure hose on the manipulator telescopic extension	<u>normal</u> log-normal	<u>903</u> 998	<u>233</u> 117	<u>0.258</u> 0.117

L_{cp} – estimate of the mean life, hours;
σ_l – estimate of the standard deviation of the life, hours;
V – estimate of the variation coefficient.

The most relevant to the data obtained law of operating time distribution between maintenances was a log-normal law with parameters $\mu = 5.514$ and $\overline{\sigma} = 0.066$ in the investigated enterprises for forwarder «John Deere» 1010 [2].

This example shows the necessity of an effective system organization of spare parts supply as this plays a significant role in the FM maintenance.

The effectiveness of diversified spare parts (SP) and operating materials (OM) stock delivery can be described by the objective function of the following form [3]:

$$L = \frac{1}{2} \cdot T \cdot \sum_{i=1}^{N} \mu_i \cdot S_i \cdot k_i + \frac{q \cdot \beta_i}{T} \cdot \left(\gamma \cdot \sum_{i=1}^{N} \frac{1}{k_i} + 1 \right) \to \min, \quad (1)$$

where L - the total cost per unit of time to ensure the supply of diversified SP and OM stock on the multiple periods system, rub.;
T - frequency of the supply, month.;
i - number of *i-th* simultaneously delivered SP and OM ($i = \overline{1, N}$);
μ_i – average demand per month, pcs./month;
S_i – price of storage for a month, rub. / month;
k_i – multiplicity of *i-th* SP and OM inclusion in the delivery list (k = 1, 2, …);
q – SP and OM delivery cost, rub.;
γ – factor increasing SP and OM delivery cost depending on their quantity when shipped, piece^{-1};
β_i – additional costs share for SP and OM supply depending on the *j-th* type of delivery vehicle ($i = \overline{1, j}$).

To solve the problem it is necessary to determine the optimal supply period T and to make the distribution of all kinds of SP and OM on the plurality of supply groups k_i, providing that the sum of the costs of the supply of L would be minimal.

The quantity of SP and OM at each delivery is calculated after determining the optimum delivery periods of diversified SP and OM sets by the following expression:

$$n_i = \mu_i \cdot T_i, \quad (2)$$

where T_i - the optimal time of *i-th* SP and OM delivery.

To select a vehicle it is necessary to determine the weight and volume of SP and OM sets delivered and to determine a vehicle according to the following conditions:

$$\sum_{i=1}^{N} m_i \cdot n_i \le M_j, \quad (3)$$

$$\sum_{i=1}^{N} v_i \cdot n_i \le V_j, \quad (4)$$

where m_i – *i-th* SP and OM weight, kg.;
M_j – tonnage of *j-th* vehicle used for delivery, kg.;
v_i – the physical volume of *i-th* SP and OM, м^3;
V_j – volume of *j-th* vehicle used for delivery, м^3.

The vehicle with specific characteristics M_j, V_j, β_i is chosen from the existing fleet of vehicles according to the conditions (3,4).

Logging companies are geographically dispersed users of logging equipment. The process efficiency of the SP distribution among storage facilities can be assessed by the following function of time loss when eliminating failures (general view):

$$T^*(\overline{X_i}) = \sum_i \min T(\overline{X_i}), \quad (5)$$

where $\overline{X_i}$ – vector of optimal allocation of *i-th* SP corresponding to the minimum total loss of time to eliminate FM failures.

The vector of optimal distribution of the number SP $\overline{X_i}$ is a controlled variable of the form

$$\overline{X_i} = \{x_0, x_1, \ldots x_n, \ldots x_M\}, \quad (6)$$

where $x_0, x_1, \ldots x_n, \ldots x_m$ – number of SP in each *m-th* storage facility, pieces ($m = \overline{0, M}$).

The total loss of time on the supply of distributed FM can be represented by the objective function:

$$T_{x_i} = t_{i,j} + t1_{i,m,j} + t2_i \to \min, \quad (7)$$

where $t_{i,j}$ – amount of time required for delivery of *i-th* SP, located directly on *j-th* FM operating site, h.;
$t1_{i,m,j}$ - the time required to deliver the necessary *i-th* SP, located at the nearest storage facility «*m*» from the *j-th* failed FM, h.;
$t2_{i}$ - amount of time required for delivery of the *i-th* SP from an external source, h.

The mathematical model for determining the number of reserved spare parts in each storage facility "m" is based on discrete-event simulation modeling representing system model development with time and implementing the approach of "time advance from event to event" [5].

4. Conclusions

1. Development of imported FM maintenance in Russia is possible through expansion of corporate maintenance and repair in specialized enterprises, developing and implementing the technology of repair and restoration of FM parts and components.

2. Implementation of a cost-effective operation maintenance system and SP and OM supply chain will expand markets for FM, generate more profit for manufacturers of forest machines and reduce service, maintenance and repair costs for consumers.

3. Organization and development of maintenance marketing and management will improve the competitiveness of FM by satisfying growing demands of consumers.

4. One of the effective tools to improve the competitiveness of FM is to improve their maintainability, that is their constructive adaptability and high-quality maintenance and repair in regular operation conditions.

5. References

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