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ASSESSMENT OF THE REPAIR INFRASTRUCTURE EFFICIENCY WITH REGARD TO MAINTENANCE OF FARM MACHINES

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ABSTRACT

Efficient repair and maintenance infrastructure, which technically supervises machines and devices in production processes, has a significant impact on the improvement of efficiency of the machine and devices application in production processes. In a present situation, with the use of complex and in many cases expensive machines with high structural and quality parameters, users may significantly influence the increase of the degree of their use through optimization of time devoted to efficient repair and maintenance treatments. The fundamental objective of the paper was to analyse the time during which farm machines stay in repair shops during periodical service and maintenance in the aspect of their performance effectiveness. The index of organizational effectiveness designated for assessment of shops which carry out maintenance of machines was determined. The relation between the coefficient of technical use of a machine and the index of effectiveness of the maintenance and repair system organization in a repair shop were determined. A functional scheme of the machine operation system was presented. This scheme in a general aspect covers functional relations of main components of the service and maintenance system of shops in the aspect of quality assessment of their particular subsystems.

Introduction

A significant factor, which directly influences the increase of effectiveness in agriculture, is a growth of agricultural mechanization, which consists in introducing to agriculture even newer machines and technical devices. According to global trends, further increase of machines' performance and reduction of expenses on maintenance and repairs are expected. The increase of effectiveness of machines and farm tractors' operation may be achieved through their constant full technical readiness. This state may be achieved at the proper system of maintenance and renovation of machines, which includes (Bocheński, 1995; Donarowicz, 2000; Dreszczyk and Malicki, 1999; Hao et al., 2010; Jurca and Ales, 2012; Kaźmierczak, 2000; Legutko, 2004; Sharma et al., 2011; Tomczyk, 2005, 2006, 2009):

– renovation of the used exploitation potential of machines through replacement of physically and economically worn machines with modern factory new ones,

– renovation of the worn exploitation potential of machines through repair of worn parts and units, including their regeneration,
– extension of the in-between-repairs exploitation course through timely maintenance of relative type and scope (technical inspection, seasonal service, campaign, guarantee, maintenance, etc.),
– improvement of organization and principles of functioning of the repair and maintenance infrastructure of a machine.

Effectiveness of the farm machines maintenance process is influenced by the quality of provided services, which may be obtained due to well trained mechanicians of the maintenance service and through the use of modern devices and improvement of the repair shops operation organization (Ahmad et al., 2011; Donarowicz, 2000; Fatemeh and Sha'ri, 2011; Jurca and Ales, 2012; Sharma et al., 2011; Wang, 2002).

Presently, the Polish agriculture is at the stage of organizational formation of the efficient and precise renovation system of machines, vehicles and farm tools based entirely on the principles of economical optimization of maintenance and repair provision.

In the discussions presented below, factors, which significantly shorten the duration of maintenance of farm machines and at the same time improve indexes of their exploitation, were analysed.

Objective and the scope of the study

The objective of the study is to present selected indexes which significantly influence the improvement of effectiveness of maintenance and repair of farm machines in the farm repair infrastructure. Moreover, the study aims at determination of the organizational effectiveness of repair shops which carry out maintenance of machines, defining a relation between the coefficient of technical use of farm equipment and the index of effectiveness of the maintenance organization system and presentation of a simplified functional scheme of operated machines. The article has a theoretical and referential character.

Materials and methods

Presently, in the repair infrastructure of agriculture maintenance, there is a maintenance system, the purpose of which is to maintain or restore full utility to technical facilities. The maintenance includes:

1. Periodical maintenance, i.e.: technical inspections, running-in servicing, within the guarantee period, campaign servicing, seasonal. maintenance, qualifying tests.
2. Repairs, i.e. current repairs (post-repair, post-inspection), preventive repairs, renovations.

Discussions presented below concern repair shops and service centres which render services both for individual farmers as well as agricultural enterprises. For the analysis of the maintenance processes indexes, rendered by a repair shop, determination of fundamental sizes, which have a significant impact on the effectiveness of its operation, is indispensable (Ahmad et al., 2011; Hao et al., 2010; Legutko, 2004; Leszek et al., 1999; Macha, 2004; Powierża, 1997; Tomczyk, 2005, 2006, 2009).

Attributes of effectiveness of machines maintenance:

Number of farm machines fit for use in a farm N_z, as follows:

$$N_z = N_o K_w \tag{1}$$

where:

N_o – total number of machines in a farm (establishment),
K_w – coefficient of technical use of machines.

Coefficient of technical use of machines K_w determines which part of time of machine's exploitation is a direct time of its use in the realization of the intended production process. The size of this coefficient may be determined from the relation:

$$K_w = \frac{t}{t + t_n + t_{pl} + t_{ot}} \tag{2}$$

where:

t – total work time between maintenances,
t_n – total time of machine stay for not planned maintenance,
t_{pl} – total time of machine stay in a reapir shop during planned periodical maintenance (technical inspection, seasonal servicing, campaign servicing, post-inspection repairs, awaiting time for spare parts or specialistic repair devices etc.),
t_{ot} – total awaiting time for technical servicing.

In order to define possibilities of increasing the number of fit machines N_z in a farm, analysis of time, when a machine stays for planned and not planned maintenance should be carried out.

Elements of time of machine stay in not planned maintenance t_n (emergency repairs) may be presented as follows:

$$t_n = t_{nocz} + t_{napr} \tag{3}$$

where:

t_{napr} – total time necessary for repair,
t_{nocz} – awaiting time for repair:

$$t_{nocz} = t_p + t_{pp} + t_{bn} \tag{4}$$

where:

t_p – time of transferring information about failure,
t_{pp} – time necessary for preparatory activities,
t_{bn} – time for arrival of repair team.

Total time for maintenance $t_{nobsł}$:

$$t_{nobsł} = t_{dgn} + t_d + t_t + t_m + t_r \tag{5}$$

where:
- t_{dgn} – time for technical diagnosis,
- t_d – time of disassembly of sub-assemblies and parts of machines,
- t_t – repair time (washing, verification, regeneration etc.),
- t_m – assembly time of dismantled elements of a machine,
- t_r – time for regulation and technical acceptance after repair.

Components of time, when a machine stays in planned maintenance t_{pl} may be presented as follows:

$$t_{pl} = t_{dgn} + t_1 + t_2 + t_3 \tag{6}$$

where:
- t_{dgn} – time for technical diagnosis, regulation and samples, technical acceptance,
- t_1 – time of dismantling unfit elements (total time indispensable for preparation of operations plus time, which is technologically indispensable for an operation),
- t_2 – time for verification and renovation works of machine units, i.e.; washing, flaw detection of damaged elements, providing new spare parts to broken up units, time for repair and total time necessary to prepare and perform the above operations),
- t_3 – time for completing, assembly and efficiency tests of elements (total time indispensable for preparing operations and time, which is technologically indispensable to perform operations).

Analysis of component times when a machine stays for emergency repair (formula 4,5) and planned (formula 6) shows that the increase of effectiveness of functioning of the maintenance system at the same technology of machines repair may be achieved mainly by shortening the duration of:
- awaiting for maintenance,
- preparatory works of maintenance,
- organization of maintenace.

Values of parameters which describe the total time, when a machine stays for emergency repair t_n and planned post-inspection repair t_{pl} may be assumed as a constant value for specific farm machine structure (e.g. a combine harvester), since it only depends on the complexity of the structure and susceptibility to maintenance of a specific machine (adjusting the structure to carry out fast repair).

On the other hand, awaiting time for repair, technical servicing and awaiting time for preparation and servicing depends mainly on the effectiveness of organization and control over maintenance and repair processes of a machine in a specific farm or a repair shop of the maintenance and repair service.

On this stage of maintenance, the efficiency of organizational solutions of cooperation of all subsystems of the maintenance and repair establishment (Fig. 1) significantly affects the improvement of effectiveness of maintenance of machines by shortening the time of

their stay in a repair shop, reduction of service costs, extension of efficiency time and their use in production processes in a farm.

On this stage of discussion, determination of the index of effectiveness of maintenance organization, which may be determined from the following relation, is crucial:

$$K_{org} = \frac{t_{nobsł}}{t_{nobsł} + \sum_{i=1}^{n} t_{ocz(i)}} \tag{7}$$

where:

K_{org} – index of effectiveness of maintenance organization,
$t_{nobsł}$ – time necessary to carry out maintenance,
t_{ocz} – awaiting time for maintenance (duration of preparatory works, gathering spare parts, tools and devices, etc.).

The increase of organization effectiveness and control over maintenance and repair of machines directly influences the increase of the index of organization effectiveness of maintenance K_{org} and the coefficient of technical use of a machine K_w. In the organization of repair shops operation, one should aim at the maximum size of the coefficient of use K_w, because it significantly influences reduction of total costs of machines and devices exploitation. On the other hand, in the exploitation practice, a tendency according to the following relation is justified and obvious:

$$K_{org} \rightarrow 1, \quad \text{a} \quad K_w \rightarrow max \tag{8}$$

A functional scheme of the operation system of machines and devices.

The size of the index of effectiveness of machines' maintenance is influenced by the structure and organization of particular subsystems of an establishment (shop) in the maintenance system of farm machines and devices. A functional scheme of such maintenance system presents a composition, structure and mutual correlation of its subsystems and components (Fig.1). In this scheme, a machinery park, repair shops and material supply are integral elements of a system, which significantly influences the subsystems S_1, S_2, … S_6. Relations, which occur between them directly influence the quality of functioning of the system of machines in the form of a fast, well done maintenance of a relative type and scope, which is commissioned to a repair shop. Analysis of processes which take place in the maintenance system of farm machines and devices shows that the system may be considered as a mass maintenance system, which consists of subsystems S_1, S_2 ,...S_6. The presented model creates a possibility for constant analysis of quality factors of each subsystem S_1, S_2 ,...S_6 on the quality of functioning of the entire servicing system.

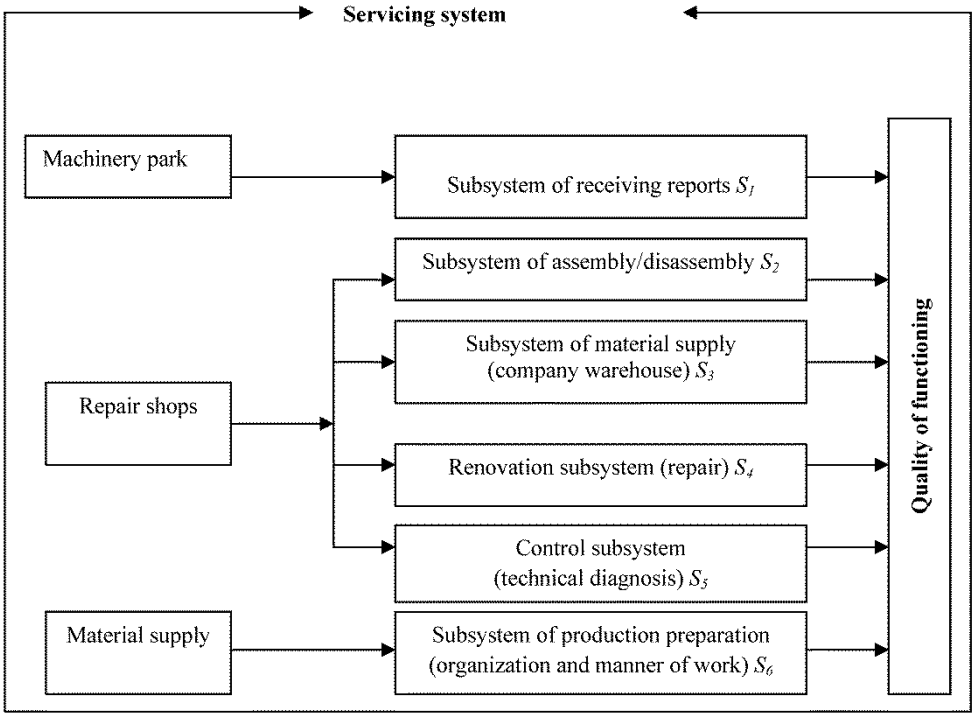

Figure 1. A functional scheme of the operation system of machines and devices

As a criterion of the functioning effectiveness of the maintenance system of farm machines and devices, minimization of production losses in agriculture as a result of failure to perform timely specific field works, e.g. ploughing, sowing of cereals, spraying, cropping etc., following from the maintenance of a machine, may be accepted, acc. to the relation:

$$K = k_1 + k_2 + k_3 \rightarrow \min \tag{9}$$

where:

- K – value of production losses, e.g.. (*PLN*),
- k_1 – awaiting time for repair and repair duration,
- k_2 – time related to organization of subsystems functioning S_1, S_2 ,...S_6, (k_1, k_2 may be expressed with a value by a product of the number of hours and unit rate),
- k_3 – costs related to the revolving fund (financial resources) on activity of specific elements of subsystems S_1, S_2 ,...S_6 (quality of equipment in tools, machines, computer programmes, number of stands etc.).

The presented scheme describes structural and functional relations of the maintenance system of farm machines and devices. Analysis of this scheme allows assumption of various variants of organization and control of servicing processes allowing at the same time determination of optimal proportions between burdening maintenance subsystems, availability and the size of a revolving fund and the number of servicing stands.

Conclusion

Farm machines and tools, which take part in production processes, require from the maintenance system to be maintained in the condition of full technical efficiency. Exploitation of farm machines and tools is a stage, during which their relevant functional quality takes a real shape. Within this period, a user of tools, has a chance to assess the quality of their performance and utility for specific work during realization of production tasks. But, it also may influence the effectiveness of the devices' use aiming at extension of time of their participation in production, e.g. agricultural through selection of repair shops, which provide maintenance of machines at optimally shortened time of their realization. The article presents the analysis of times within the scope of machines' maintenance. The presented analysis allows assessment of the effectiveness of organization of machines' maintenance, which results in the suggested index of assessment of its organization effectiveness. The fundamental aim of activities of a machine's user is maintaining high quality maintenance and aiming at shortening the time of preparation and operation of maintenance (treatments), renovation and maintenance of machines (i.e. time of staying in a repair shop), and thus reduction of maintenance costs and costs of extension of time of their use in production (in particular in agrotechnical periods of the most important field works – sowing, harvesting, lifting, etc.) Optimal selection of the relevant structure and organization of cooperation of particular subsystems, which are included in the maintenance system of machines (Fig. 1) may be significantly influenced both by the quality of their functioning through the control system (self-control) of each subsystem on further stages of realization of the machine maintenance as well as shortening its duration.

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OCENA EFEKTYWNOŚCI ZAPLECZA NAPRAWCZEGO W ZAKRESIE OBSŁUG TECHNICZNYCH MASZYN ROLNICZYCH

Streszczenie. Na poprawę efektywności wykorzystania maszyn i urządzeń w procesach produkcyjnych w dużej mierze ma wpływ sprawnie działające zaplecze obsługowo-naprawcze, sprawujące nad nimi nadzór techniczny. W obecnej sytuacji, dysponując skomplikowanymi i w wielu przypadkach kosztownymi maszynami o wysokich parametrach konstrukcyjno-jakościowych, użytkownicy mogą w istotny sposób wpływać na zwiększenie stopnia ich wykorzystania poprzez optymalizację czasów poświęconych na sprawne przeprowadzenie zabiegów obsługowo-naprawczych. Zasadniczym celem pracy była analiza czasu przebywania maszyn rolniczych w warsztatach podczas wykonywania obsług okresowych i napraw w aspekcie efektywności działania tychże warsztatów. Wyznaczono wskaźnik efektywności organizacyjnej przeznaczony do oceny warsztatów przeprowadzających obsługi techniczne maszyn. Określono zależność pomiędzy współczynnikiem wykorzystania technicznego maszyn i wskaźnikiem efektywności organizacji systemu obsługi i napraw w warsztacie. Przedstawiono schemat funkcjonalny systemu obsługiwania maszyn. Schemat ten w ujęciu ogólnym ujmuje powiązania funkcjonalne głównych elementów systemu obsługowo-naprawczego warsztatów w aspekcie oceny jakościowej poszczególnych ich podsystemów.

Słowa kluczowe: maszyna rolnicza, obsługa techniczna, naprawa, efektywność, czas obsługi technicznej