Zenon GRZEŚ, Ireneusz KOWALIK, Piotr RYBACKI
Instytut Inżynierii Biosystemów, Uniwersytet Przyrodniczy w Poznaniu
ul. Wojska Polskiego 28, 60-637 Poznań, Poland
e-mail: zgrzes@au.poznan.pl

Received: 2016-10-12 ; Accepted: 2017-01-24

COMPARATIVE ASSESSMENT OF AGRICULTURAL TRACTOR SERVICEABILITY

Summary

The aim of this study was to assess technical feasibility of servicing for modern agricultural tractors. Labour intensity of technical service during the entire servicing cycle was adopted as a measure of serviceability for agricultural tractors. Among tractors included in this study the lowest labour intensity of technical service (P_{st} = 25 h) was observed for Forterra 105 tractors by Zetor.

***Key words**: technical service, serviceability, technical feasibility of servicing, technical inspection, labour intensity, agricultural tractors*

OCENA PORÓWNAWCZA PRACOCHŁONNŚCI SERWISOWEJ CIAGNIKÓW ROLNICZYCH

Streszczenie

Celem pracy była ocena technologiczności serwisowania współczesnych ciągników rolniczych. Jako miarę podatności serwisowej ciągników rolniczych przyjęto pracochłonność serwisu technicznego w okresie pełnego cyklu serwisowego. Spośród ciągników objętych badaniami najmniejszą pracochłonność serwisu technicznego (P_{st} = 25 h) zaobserwowano w przypadku ciągników marki Zetor Forterra 105.

***Słowa kluczowe**: serwis techniczny, podatność serwisowa, technologiczność serwisowania, przegląd techniczny, pracochłonność, ciągniki rolnicze*

1. Introduction

The subsystem of technical maintenance is an integral part of operation and maintenance of agricultural machines. At present in scientific publications this subsystem is increasingly often referred to a technical servicing of machines [1, 4, 5, 6, 7, 8, 9]. This term is commonly applied also in the operational practice of machines. Nevertheless an efficient and effective performance of technological processes of technical servicing performed during machine operation depends on actions undertaken at the stage of machine design, engineering and manufacture. It is at these stages of service life of a technical object that machine serviceability is determined. Adaptation of machines to easy and rapid performance of individual technical service operations is referred to a serviceability or technical feasibility of servicing. Occasionally the term repairability is also used to denote adaptation of a machine or device to easy and rapid performance of operations comprising the technological repair (overhaul) process. Technical feasibility of technical inspections may be similarly defined. These terms are treated as specific reference to technical feasibility of servicing [10, 12, 13].

There are several structural characteristics required for machines characterised by a good technical feasibility of servicing. The most important of these include easy access to locations where adjustment, control and replacement of operating fluids are performed, a relatively small number of lubrication and operating fluid replacement processes as well as their small variation, at the relatively small number of tools required to perform technical maintenance operations [12].

In terms of technical feasibility of servicing for agricultural machines an important aspect is also connected with the easy washing and cleaning of a given machine as well as its assemblies and parts. A general requirement for technical feasibility in machine washing and cleaning processes is to ensure complete cleaning of the largest possible number of parts in the main stream of the mechanical washing system. Moreover, in order to ensure good efficiency of technical servicing of machines we should provide structural separateness of individual assemblies, referred to a modularity or panel structure of the design [13]. Structural separateness of assemblies facilitates to easy disassembly one assembly with not disruption of the structure and regulation of the other assemblies. Good technical feasibility of maintenance is also connected with a good access and easy disassembling of wear parts, use of readily disassembled connections, e.g. threaded joints with a large pitch, snap fasteners and elastic connectors, as well as identifiability of individual assemblies, parts and connections. Nevertheless, certain requirements of technical feasibility of servicing occasionally are incompatible with part manufacturing technologies. An example may be provided here by the easy assembly, which may not be readily provided when applying highly efficient connection methods such as fusion and pressure welding or various plastic working methods [10]. Machines designed to ensure such properties facilitate an easy and efficient technical servicing process.

While practical operation of agricultural machines provides much information on characteristics of machines with good technical feasibility of servicing operations, there is no objective method available for the valuation of this important utility characteristics of presently used agricultural machines. For this reason maintenance feasibility and repairability analyses are used to assess and ensure functional quality of machines [15].

2. Aim of the study

The primary aim of this study was to assess technical feasibility of servicing for presently used agricultural tractors, being primary sources of tractive force in Polish agriculture. Assessment of this basic functional characteristics

of modern agricultural tractors is based on the criterion of labour intensity in the performance of service operations. For this reason it was decided in this study to analyse labour intensity of servicing maintenance for selected agricultural tractors.

This analysis required for the realisation of the abovementioned aim facilitates a comparative evaluation of various types of tractors in terms of their serviceability. Moreover, it will broaden our knowledge on the subject by providing a set of information on serviceability of modern agricultural tractors.

3. Material and methods

Labour intensity of technical servicing is a measure of adaptation of agricultural tractors to an efficient and quick performance of servicing operations [10]. However, due to the variation in servicing systems for individual types of agricultural tractors it was assumed in this study that labour intensity of servicing maintenance during one servicing cycle is a measure of serviceability evaluation. The maintenance cycle of a tractor is the amount of work performed by a tractor between two inspections of the greatest scope of works or from the beginning of its life cycle to the first inspection with the largest scope of works [10]. In each servicing cycle a specific number of cyclical services, such as e.g. periodical inspections, is performed in a pre-specified order and specific time intervals. Thus the total labour intensity of technical service P_{st} within a specific time interval was established based on the following dependence:

$$P_{st} = \sum_{i=1}^{k} p_i \cdot n_i, \; h \qquad (1)$$

where:

p_i – labour intensity of servicing maintenance of the i-th type, h,

n_i – the number of servicing operations of the i-th type within a specific time interval,

k – the number of types of servicing operations within a specific time interval.

In accordance with the developed theoretical foundations for the evaluation of serviceability of agricultural tractors analyses of labour intensity were conducted for technical servicing performed at the Toral authorised servicing station in Gostyń (the Wielkopolska province), offering servicing for analysed tractors. Labour intensity of technical service was determined using the time study method. The time study included measurement of time required for the performance of individual service actions and operations in accordance to the scope of the servicing work recommended by the manufacturer of a given tractor. Time was measured by an adequately trained employee, well-acquainted with technological processes of technical inspections of tested tractors. The same worker performed time keeping operations for all types of tested tractors. Moreover, time keeping operations were performed under comparative conditions at the servicing station, using identical service and repair equipment [3].

Labour intensity of technical service was analysed for selected agricultural tractors with a comparable design and intended use. Analyses were conducted for selected tractors, characterised by similar power rating, i.e. Same Explorer 3 100 (70.5 kW), Pronar 5135 (74 kW) and Zetor Forterra 105 (74 kW). The duration of the servicing cycle for selected tractors, measured by the number of worked motor hours, varied and amounted to 1200, 1000 and 1500 mth. In the servicing cycle within the established time intervals and the established order a total of 4-5 various types of technical inspections were performed, depending on the tractor type.

4. Results

Tables 1-3 present measured labour intensity for technical inspections performed for individual tested tractors. Labour intensity data include the total time of all servicing operations to be performed as recommended by manufacturers of tested agricultural tractors. The number of servicing operations for individual services ranged from 17 to 26, depending on the scope of inspection and the type of tractor. Since studies on labour intensity for tractor servicing concerned the first servicing cycle, the recorded results include also labour intensity of technical inspections performed in the initial service life period (the so-called warranty inspections). These inspections, following the recommendations of their manufacturers, were performed after the first 50 or 80 motor hours of work of tested tractors.

Based on the measured labour intensity of individual technical inspections the total labour intensity of technical servicing was established in the period of one maintenance cycle of tractors included in the study. According to equation (1) the obtained total values of labour intensity of technical servicing P_{st} involve repeatability of performance of individual services comprising the entire servicing cycle for the tested tractors (Fig. 1).

The lowest total labour intensity of technical servicing during the entire maintenance cycle of tested tractors was found for Zetor Forterra 105 tractors. The total performance time for all technical inspections comprising the maintenance cycle of this tractor was 25 h. Moreover, we need to stress here that the Zetor Forterra 105 tractor had the longest duration of the maintenance cycle of 1450-1500 mth.

Table 1. Labour intensity of technical service of Same Explorer 3 100DT agricultural tractors
Tab. 1. Pracochłonność serwisu technicznego ciągników rolniczych Same Explorer 3 100DT

No.	Frequency of technical inspection [mth]	Number of service operations [-]	Labour intensity of technical inspection p_i [h]	Number of inspections within the service cycle n_i [-]
1.	50	20	5,75	1
2.	300	22	6,25	2
3.	600	25	8,75	1
4.	1200	25	9,50	1
Total		92	36,50	5

Source: the authors' study / Źródło: opracowanie własne

Table 2. Labour intensity of technical service of Pronar 5135 agricultural tractors
Tab. 2. Pracochłonność serwisu technicznego ciągników rolniczych Pronar 5135

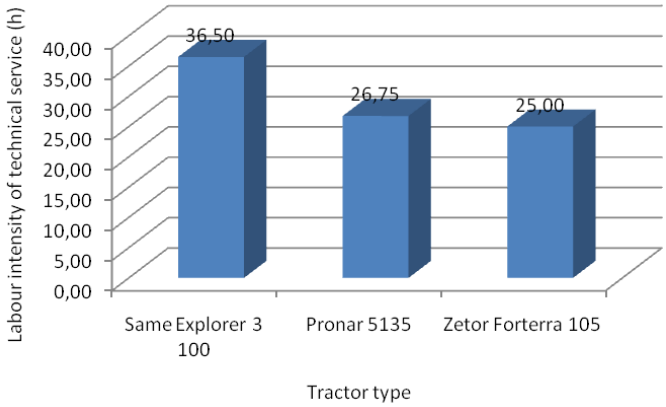
Lp.	Frequency of technical inspection [mth]	Number of service operations [-]	Labour intensity of technical inspection p_i [h]	Number of inspections within the service cycle n_i [-]
1.	50	19	5,25	1
2.	250	17	4,00	1 (2)
3.	500	22	5,50	1
5.	1000	23	8,00	1
Total		81	26,75	5

Source: the authors' study / Źródło: opracowanie własne

Table 3. Labour intensity of technical service of Zetor Forterra 105 agricultural tractors
Tab. 3. Pracochłonność serwisu technicznego ciągników rolniczych Zetor Forterra 105

Lp.	Frequency of technical inspection [mth]	Number of service operations [-]	Labour intensity of technical inspection p_i [h]	Number of inspections within the service cycle n_i [-]
1.	80-100	23	5,25	1
2.	450-500	25	7,25	1
3.	950-1000	26	6,25	1
4.	1450-1500	26	6,25	1
Total		100	25,0	4

Source: the authors' study / Źródło: opracowanie własne



Source: the authors' study / Źródło: opracowanie własne

Fig. 1. Labour intensity of technical servicing during the maintenance cycle of tested agricultural tractors
Rys. 1. Pracochłonność serwisu technicznego w okresie cyklu obsługowego badanych ciągników rolniczych

In the case of the other tractors the total labour intensity of servicing performed during the first maintenance cycle was 26.75 h for Pronar 5135 and 36.5 h for Same Explorer 3 100. Values P_o obtained for these tractors are greater in comparison to those recorded for Zetor Forterra 105 (P_{st} = 25 h), even though Pronar 5135 and Same Explorer 3 100 tractors have shorter maintenance cycles of 1000 and 1200 mth, respectively.

5. Concluding remarks

Technical feasibility of servicing is an important operating characteristics of modern tractors and agricultural machines. The term serviceability is understood as a set of characteristics determining adaptation of a design to performed actions and servicing operations. Available literature lacks data on serviceability of presently used agricultural machines. For this reason an important problem in agricultural engineering is connected with the evaluation of this crucial utility characteristics of currently manufactured agricultural machines. Moreover, an extension of the set of data related with technical feasibility of tractor servicing is essential for the decision-making process for the selection of a tractor for a given farm [2, 11, 14].

Based on the performed measurements and calculations as well as recorded observations the following final conclusions were formulated:

1. For this reason labour intensity of technical service is the measure of serviceability adopted in this study for agricultural tractors. It is understood as the amount of time required for the performance of individual technical inspections during one servicing cycle.
2. Among tractors tested in this study the lowest labour intensity of technical service was found for the Zetor Forterra 105 tractor. The total labour intensity of technical inspections performed during the first maintenance cycle of this tractor was 25 h. Other tractors had greater values of labour intensity for servicing operations, amounting to 26.75 h (Pronar 5135) and 36 h (Same Explorer 3 100).

3. Lower values of labour intensity for technical maintenance indicate better serviceability of individual tractors. Moreover, a potential consequence of lower labour intensity of technical service may lead to a reduction of its costs.

6. References

[1] Bocheński C, Klimkiewicz M., Kojtych A.: Wybrane zagadnienia z technicznej obsługi pojazdów i maszyn. Warszawa: Wydawnictwo SGGW, 2001.

[2] Francik S.: Ocena nowoczesności maszyn na przykładzie ciągników rolniczych. Inżynieria Rolnicza, 2003, 10(52): 7-15.

[3] Gaszek W.: Technologiczność przeglądów technicznych ciągników rolniczych. Praca magisterska. Maszynopis. Uniwersytet Przyrodniczy w Poznaniu, 2011.

[4] Jósko M., Kołodziejski D.: Wybrane problemy eksploatacyjne pojazdów i maszyn rolniczych w zakresie ich serwisowania. Journal of Research and Applications in Agricultural Engineering, 2008, 53(2): 5-7.

[5] Juściński S., Piekarski W.: Eksploatacja pojazdów rolniczych w aspekcie struktury popytu na usługi przeglądów serwisowych. [Operation of agricultural vehicles in view of the structure of demand for servicing inspections]. Eksploatacja i Niezawodność - Maintenance and Reliability, 2010, 1: 60-68.

[6] Juściński S., Piekarski W.: Analiza statystyczna obsługi serwisowej ciągników rolniczych w aspekcie odległości od siedziby firmy. [Statistical analysis of servicing of agricultural tractors depending on the distance from the company location]. Inżynieria Rolnicza, 2008, 2 (100): 57-66.

[7] Juściński S., Piekarski W.: An analysis of the territorial range of farm tractors servicing realised as an element of distribution logistics. Technical Sciences. Uniwersytet Warmińsko-Mazurski w Olsztynie, 2008, 11: 59-65.

[8] Juściński S., Piekarski W:. Zarządzanie logistyczne autoryzowanym serwisem ciągników i maszyn rolniczych. [Logistic management of authorised servicing of tractors and agricultural machines]. Eksploatacja i Niezawodność - Maintenance and Reliability, 2008, 2: 25-33.

[9] Juściński S., Piekarski W.: Rozkład zapotrzebowania na przeglądy serwisowe ciągników rolniczych w aspekcie terminów agrotechnicznych. [Distribution of demand for servicing inspections of agricultural tractors depending on cultivation dates]. Inżynieria Rolnicza, 2009, 8 (117): 31-38.

[10] Legutko S.: Eksploatacja maszyn. Wydawnictwo Politechniki Poznańskiej, 2007.

[11] Rybacki P.: Investigation of the decision-making process of service station selection for agricultural tractors with the assistance of the AHP method. Journal of Research and Applications in Agricultural Engineering, 2011, 56(2): 126-130.

[12] Rzeźnik C., Durczak K., Rybacki P.: Serwis techniczny maszyn. Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu, 2015.

[13] Rzeźnik C.: Podstawy obsługi technicznej maszyn rolniczych. Wydawnictwo Akademii Rolniczej w Poznaniu, 2008.

[14] Skudlarski J.: Poziom obsługi posprzedażnej jako kryterium oceny wizerunku producentów ciągników i maszyn rolniczych. Technika Rolnicza Ogrodnicza Leśna, 2006, 3: 18-20.

[15] Żółtowski B,. Tylicki H.: Wybrane problemy eksploatacji maszyn. Państwowa Wyższa Szkoła Zawodowa, Piła, 2004.