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**ELECTRONIC
JOURNAL
OF POLISH
AGRICULTURAL
UNIVERSITIES**

2012
Volume 15
Issue 4
Topic
**AGRICULTURAL
ENGINEERING**

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JUŚCIŃSKI S., 2012. A SURVEY ON THE STRUCTURE OF SERVICING ACTIVITIES CARRIED OUT WITHIN THE
TECHNICAL MAINTENANCE SERVICES OF FARM VEHICLES AND MACHINES, EJPAU, 15(4), #01.

Available Online <http://www.ejpau.media.pl>

A SURVEY ON THE STRUCTURE OF SERVICING ACTIVITIES CARRIED OUT WITHIN THE TECHNICAL MAINTENANCE SERVICES OF FARM VEHICLES AND MACHINES

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ABSTRACT

The study presents an analysis of issues concerning technical maintenance of domestic agricultural production. Actions in the area of maintaining the technical readiness of farm vehicles and machines offered by producers in authorised distribution networks were characterised. Internal and external factors occurring in the process of the operation of products were presented. Requirements addressed to authorised servicing points and works carried out by servicing point employees were discussed. The survey also included technical maintenance, i.e. pre-sales inspections, and inspections and repairs carried out during and after the warranty period. The series of surveys included the years 2003-2010. The surveys were conducted in the enterprise carrying out authorised distribution and servicing activities of farm vehicles and machines. The quantitative structure of the servicing was presented in a graphic form and was subject to a statistical analysis with the use of the R program, version 2.14.1. The trend as well as random and seasonal fluctuations for a series of monthly observations were defined. The temporal distributions of the work conducted by the Service Department were analysed and evaluated in the context of the calendar of agrotechnical operations.

Key words: technical maintenance of farm vehicles and machines, servicing, logistic distribution services.

INTRODUCTION

In the conditions of the market economy, the domestic agricultural production must ensure the profitability of activities. A significant component of the costs incurred by farmers is the technical maintenance consisting of farm vehicles and machines inspections and repairs [15, 23, 25]. Most private farms still operate according to this model, which assumes that a farmer has all the machines necessary to conduct agricultural activity. This constitutes a large

burden in terms of investments and operation, which has a direct impact on the farms' competitiveness. A reduction of expenditures is hindered due to weakly developed services in the area of agrotechnical work and operations. The lack of a broad and diversified service range on the market results both from the short, seasonal demand and the specificity of the industry of agricultural crops producers in Poland.

The economic conditions force farmers to seek cost reduction in the area of technical maintenance. A maintenance point offering services of the highest quality and competitive prices constitutes one of the most important conditions determining the choice of the brand of a farm vehicle or machine purchased by clients [4, 11]. The market practice confirms the rule that the purchase of the first machine depends on a good salesperson, and buying further products - on the excellent work of mechanics from the Service Department [3, 17, 20].

In relation to the above, producers, by creating sales networks, attempt to create professional technical maintenance department within their dealing activities. High requirements concerning the level of the inspections and repairs performed are multidimensional [5, 14]. An authorised dealer must meet the conditions concerning the size of the workshop stands, the technical equipment and gear necessary for repairs and for removing defects. Advanced construction-related and technological solutions applied to subassemblies, particularly of self-propelled vehicles and machines, require specialist diagnostic equipment for conducting periodic inspections of their technical condition [18, 19, 21].

The basic factor determining efficient technical maintenance, both in the aspect of its quality and timeliness, is the staff policy conditioning employment in the Service Department. The high qualifications of the management staff and mechanics include technical education and practical preparation for the profession.

Carrying out pre-sales inspections, inspections after subsequent operation periods, and warranty and post-warranty repairs are connected with the tasks implemented in authorised workshops, in agricultural holdings and in the field.

THE RESEARCH PROBLEM AND METHOD

Technical objects in the operation process are subject to various internal and external factors of both objective and subjective nature. The process of farm vehicle and machine operation involves a number of external operative factors in the form of varying loads on the construction and particular subassemblies. In turn, the external factors take the form of various meteorological constraints such as temperature and humidity, as well as chemical, biological and mechanical factors. Anthropotechnical factors, including operators' qualifications and skills, and the rules and nature of equipment operation, are also of large importance [12, 22].

A random configuration of the conditions and constraints on the operation result in a very diversified technical conditions of particular vehicles and machines after subsequent seasons or periods constituting the life-cycle recommended by the producer. This creates the necessity to customise the planning and realisation of particular orders by the Service Department. For this purpose, the ability to verify the defects reported by the users is necessary, together with experience in the unassisted realisation of technical maintenance tasks. The service activities also involve the ability to prepare a cost estimate of repairs, settling the work carried out, and completing the complaint procedure according to the warranty conditions. The structure of servicing, due to the diversity of tasks, requires updating the knowledge and skills of the technical staff. The producers of farm vehicles and machines offer periodic training packages to the cooperating dealers, aiming at ensuring a uniform standard of the services provided in the entire distribution network of the company. Raising qualifications both in the basic scope for newly employed persons, and supplementary training for other employees, is to ensure that the knowledge of the construction and operation rules of all types of equipment used goes along with introducing new products to the market [6, 9, 10].

The area requiring research and analysis is the quantitative and temporal instability of demand for servicing of farm vehicles and machines. The changes in the demand for inspections and repairs occurring in the subsequent months of the calendar year constitute an essential problem for logistic systems in terms of planning and managing the services of the maintenance point [7, 8, 12].

The purpose of the market research was to recognise and analyse the quantitative structure of inspections and repairs of farm vehicles and machines carried out by an authorised Service Department in the warranty and post-warranty period.

The series of surveys was implemented in a trade and services enterprise. The business entity in which the surveys were carried out is an authorised distributor of farm vehicles and machines, carries out their servicing and conducts the sales of the full range of spare parts. The enterprise has been present on the market since late 1980s, constantly implementing distribution and service activities in central-eastern Poland. The object of the surveys carried out in the years 2003-2010 was the Service Department operating within the structure of the enterprise.

The full range of inspections and repairs carried out within technical maintenance during the eight survey years included the following brands of farm tractors: John Deere, Zetor, Same, Deutz Fahr, Lamborghini and Pronar. The servicing concerned farm machines produced by such concerns as John Deere, Väederstad, Kuhn, Lemken, Kongskilde, Hardi, Manitou and Joskin, as well as machines produced by domestic enterprises forming the UNIA Group, i.e. Unia Grudziądz, Kraj Kutno, Agrometr Brzeg, Pilmet Brzeg and Famarol Słupsk, and Akpil i Metaltech enterprises. In the case of John Deere, Kuhn and Väederstad concerns, the enterprise in which the surveys were carried out conducted technical maintenance services as the general dealer in the Lubelskie Voivodeship, while for the remaining producers this was local servicing work.

THE RESULTS OF THE SURVEYS CONCERNING SERVICING ACTIVITIES CARRIED OUT IN THE YEARS 2003-2010

Within 8 years the Service Department performed 9 310 inspections and repairs within the technical maintenance activities of farm vehicles and machines. The quantitative distribution of servicing activities in the warranty and post-warranty periods in monthly terms is presented in the histogram (Fig. 1).

The surveys of the orders structure in the period 2003-2010 confirmed the realisation of (Fig. 2):

- 1842 pre-sales inspections (P0),
- 1778 warranty inspections (PG),
- 278 post-warranty inspections (PP),
- 2794 warranty repairs (NG),
- 2618 post-warranty repairs (NP).

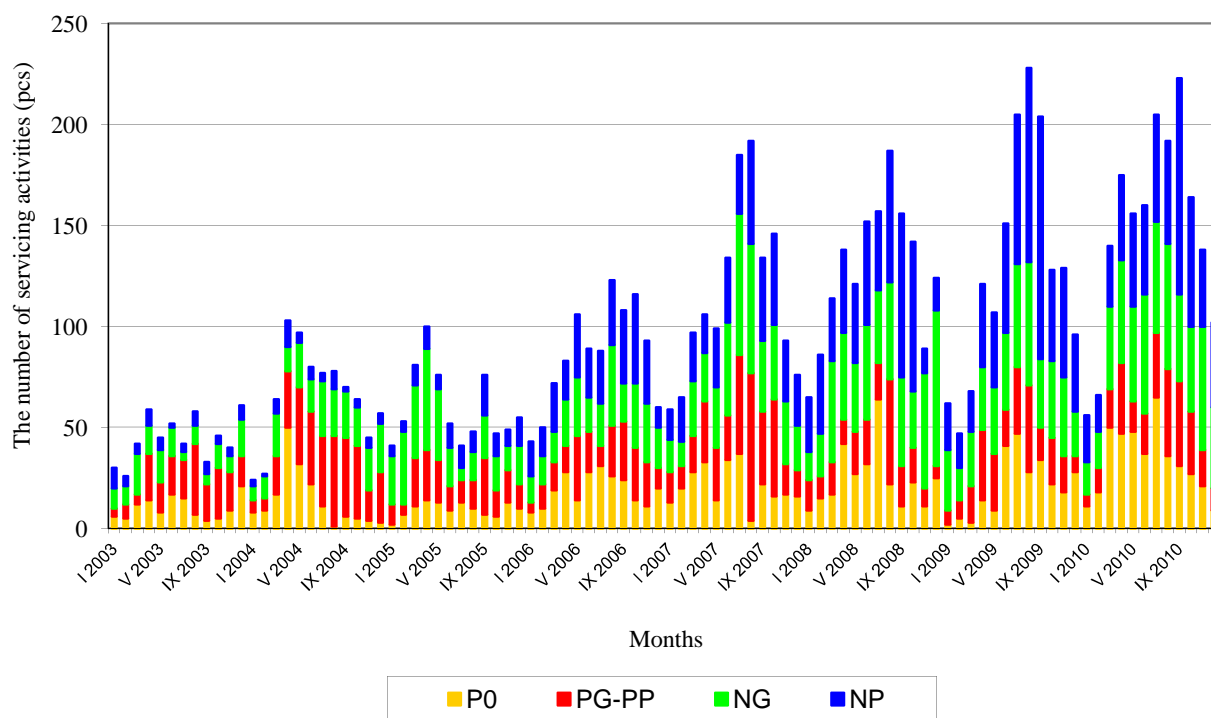


Fig. 1. The quantitative distribution of warranty and post-warranty inspections repairs of farm machines and vehicles in the years 2003-2010 [The author's own study]

In 2003 534 inspections and repairs were carried out. The highest number of orders for technical maintenance activities relating to farm vehicles and machines was recorded in April, August and December, while the lowest in January, February and September. The orders dominating in the surveyed period were service inspections, while post-warranty repairs constituted the least numerous group (Table 1). Servicing activities in quarterly terms were at the lowest level in the first quarter, and at the highest in the second quarter (Table 2).

Table 1

The distribution of servicing activities carried out within the technical maintenance services of farm vehicles and machines

No.	The type of servicing activities	2003	2004	2005	2006	2007	2008	2009	2010
		%	%	%	%	%	%	%	%
1	PO	23,0	21,4	16,0	22,6	18,3	19,5	16,2	22,5
2	PG-PP	38,2	41,7	26,6	21,1	25,7	14,3	16,6	16,0
3	NG	26,0	28,8	40,2	26,4	29,9	32,6	27,2	30,1
4	NP.	12,8	8,1	17,2	29,9	26,1	33,6	40,0	31,4
<i>In general:</i>		<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>

Source: Author's own analysis

Table 2

The quarterly structure of the number of servicing activities carried out within technical maintenance services of farm vehicles and machines

No.	The sales realisation time	2003	2004	2005	2006	2007	2008	2009	2010
		%	%	%	%	%	%	%	%
1	I quarter	18,4	14,7	24,3	16,0	15,9	17,3	11,5	14,8
2	II quarter	29,2	35,6	31,7	27,0	24,5	26,8	24,5	27,6
3	III quarter	24,9	28,6	23,0	30,9	36,9	32,7	41,2	34,9
4	IV quarter	27,5	21,1	21,0	26,1	22,7	23,2	22,8	22,7
<i>In general:</i>		<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>	<i>100,0</i>

Source: Author's own analysis

In 2004 the Service Department carried out 786 inspections and repairs. In comparison to the previous year, the number of orders increased by 47.2%. The highest demand was recorded in April and May, and the lowest in January, February and November. The most frequent were warranty inspections, and post-warranty repairs were carried out the least often. The minimum periodic demand for services was recorded in the first quarter, and the maximum demand was observed in the second quarter. In 2005 719 technical maintenance orders were completed. In the year-on-year comparison, a drop by 8.5% was recorded. The lowest demand for equipment repairs was identified in January, July and October, and the highest in March and April. In the surveyed period, the most numerous were warranty repairs, and the least – pre-sales inspections. The minimum number of repairs was completed in the fourth and the maximum in the second quarter of the analysed year. In 2006 1031 servicing activities were carried out. The maximum demand was recorded in the third and the minimum in the first quarter. In relation to the previous year, a 43.4% growth was identified. The most frequent were post-warranty repairs, while inspection activities were the least numerous. The highest demand for inspections and repairs occurred in August, September and October, and the lowest in January, February and December.

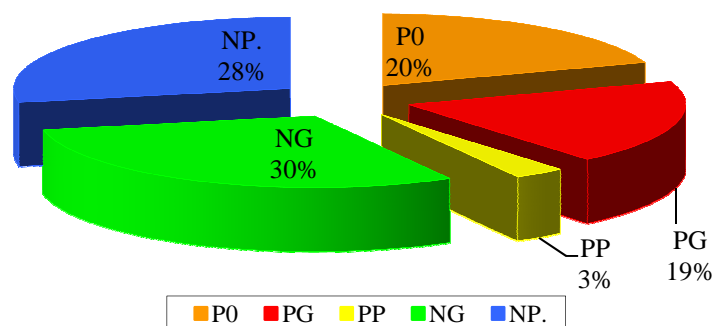


Fig. 2. The structure of the share of warranty and post-warranty repairs of farm machines and vehicles in the technical maintenance activities for the period 2003-2010 [The author's own study]

In 2007 1386 orders for technical maintenance activities were completed. The number of activities was the highest in the third quarter, and was at a minimum level at the beginning of the year. In relation to the previous year, a 34.4% increase in services was recorded. The prevailing type of activities were post-warranty repairs, and the least numerous were pre-sales inspections. The highest level of orders was identified in July, August, and October, and

the lowest in January, February and December. In 2008 the Service Department completed 1531 orders. In the year-on-year comparison, this constituted a 10.5% growth. The minimum numbers of servicing activities were carried out at the beginning of the year, and the maximum – in the third quarter. The lowest number of activities was completed in January, February and November, and the highest in July, August and September. In the structure of orders by type, a high level of warranty and post-warranty repairs was recorded, while the number of warranty inspections was the lowest. In 2009 1546 servicing activities were completed. Post-warranty repairs constituted the dominant type of activities, and the analysed period demonstrated a low demand for pre-sales and operation inspections. The largest number of orders occurred in July, August and September, while the lowest - in January, February and March. In relation to the previous year, a 1.0% growth was recorded. The minimum periodic demand was indicated at the beginning of the year, and the maximum in the third quarter. In 2010 the Service Department carried out 1777 inspections and repairs. In the year-on-year comparison, a 14.9% growth was observed. The largest numbers of services were ordered by vehicles and machines users in July, August and September, while the lowest in January and February. The highest demand was recorded in the third and the minimum in the first quarter. Warranty and post-warranty repairs constituted the most frequent type of activities carried out by the Service Department, while the number of orders for inspections was the lowest.

THE STATISTICAL SURVEY METHOD

The results of the servicing activities surveys implemented within the technical maintenance of farm vehicles and machines, including pre-sales (P0), warranty and post-warranty inspections (PG-PP), warranty repairs (NG) and post-warranty repairs (NP), were arranged in the form of monthly observations. The obtained time series Y_t was subject to a statistical analysis in order to describe the characteristics of phenomena occurring during servicing activities. The changes in the demand structure for inspections and repairs was analysed in the context of work and operations carried out in agricultural holdings within the calendar year. Preparing random variables made it possible to determine the trend, and random and seasonal fluctuations. Services provided in the agricultural industry were the basis for identifying the length of rolling periods $d = 1, 2, \dots, 12$. The analysis of the servicing activities was performed with the use of the multiplicative model of time series components, which describes the following correlation [1, 16]:

$$Y_t = T_t \cdot S_t \cdot C_t \cdot I_t \quad (1)$$

where: Y_t – the value of the series,
 T_t – the trend of the series,
 S_t – seasonal fluctuations,
 C_t – cyclical fluctuations,
 I_t – random fluctuations.

The time series adjustment was carried out by applying centred moving averages. The value of centred moving averages for particular levels of the time series is presented by the following equation:

$$\bar{y}_t^{(d)} = \frac{1}{d} \left(\frac{1}{2} y_{t-\frac{d}{2}} + \sum_{t=t_0}^{t+t_0} y_t + \frac{1}{2} y_{t+\frac{d}{2}} \right), \quad t_0 = \frac{d}{2} - 1 \quad (2)$$

The value of seasonal indices for the multiplicative model is described by the formula:

$$O_i = \frac{1}{c} \left[\sum_{t=1}^c \frac{y_{t_i}}{\bar{y}_t^{(d)}} \right] \cdot 100 WK^{(M)} \quad (3)$$

where c – the number of periodicity cycles

$WK^{(M)}$ – the average multiplicative adjustment index to obtain $\sum_{i=1}^{12} O_i = 1200$.

The adjustment index was determined on the basis of the following equation:

$$WK^{(M)} = \frac{100 \cdot d}{c \sum_{t=1}^c \frac{y_{t_i}}{\bar{y}_t^{(d)}}} \cdot 100 \quad (4)$$

The value of random fluctuations for the multiplicative index is presented in the formula:

$$y_{t(skor)}^{(M)} = \frac{y_t}{O_t} \cdot 100 \quad (5)$$

The trend of the weighted average from 5 periods was determined according to the following equation:

$$\hat{y}_t^{(M)} = \bar{y}_t^{(5)(M)} = \frac{1}{g} \sum_{t-2}^{t+2} y_{t(skor)}^{(M)} \cdot w_t \quad \text{for } [w_t] = \begin{bmatrix} 1 \\ 2 \\ 3 \\ 2 \\ 1 \end{bmatrix} \quad (6)$$

The average level for seasonal indices equals 100%. This value constitutes a reference for the graphic analysis of seasonal fluctuations on the distribution of the set of variables. The statistical analysis of the surveys on the technical maintenance of farm vehicles and machines was carried out with the use of the R program, version 2.14.1 for Windows [2, 24].

THE STATISTICAL ANALYSIS OF SERVICING ACTIVITIES IN THE YEARS 2003-2010

Inspections and repairs of farm vehicles and machines carried out in warranty and post-warranty periods by the dealer company service in the period 2003-2010 had a variable quantitative structure (Fig. 3). The demand for technical maintenance increased proportionately to the number of farm vehicles and machines purchased and used in the area of the distribution and servicing activities. The gradual increase in the population of products is confirmed by the growth in the number of technical maintenance orders. Within the first three years, the number of services was at a level lower than the one obtained during the subsequent periods under analysis.

The change in the number of particular types of servicing activities resulted both from their specificity and the completion method. It should be emphasised that the changes in the technical servicing activities happened within the successive months of the particular years, also in the form of an increase in the annual demand.

Pre-sales inspections, carried out only once during the preparation for handing the product to the client, depended on the results obtained by the Sales Department. The work of the Service Department concerning new products concentrated on inspections which users were obliged to carry out according to the warranty conditions.

Post-warranty inspections were of a facultative nature for purchasers and constituted a factor strongly reducing their quantitative structure. An important feature of inspections was their periodic cyclicity after the recommended hours of operation constituting the life-cycle of a given vehicle or machine. The number of repairs carried out in the initial period of operation at the producer's cost, within the warranty, depended both on the production quality, material defects or errors in the installation process, and the population of vehicles and machines included in the warranty period. The gradual changes in the age structure caused a rise in the number of products subject to post-warranty repairs.

The analysis indicates significant differences in the number of servicing activities conducted in the successive months. The growth in demand for technical maintenance in the form of inspections and repairs also lead to a deepening of differences in the structure of the number of orders completed in the subsequent years. The range between the lowest and the highest level of servicing activities for particular monthly periods was from several dozen to several hundred percent. The comparison of the number of orders recorded in the first and the last year of the surveys indicated a nearly threefold growth in demand. The increase in demand for work connected with the technical maintenance of vehicles and machines required a development of the Service Department in terms of organisation and equipment.

Carrying out eight-year surveys of comprehensive technical maintenance of farm vehicles and machines made it possible to determine the trend, which is the graphic reflection of the changes in demand for inspections and repairs carried out by the authorised service point (Fig. 4). In 2003 and in the first quarters of 2004, a growing trend was recorded. From the fourth quarter of 2004 and through the majority of 2005, a declining trend was observed, with periods of a lateral trend during the stagnation of demand. From the end of 2005 to the middle of 2008 the growing trend with a variable dynamics was recorded. In the remaining survey period, the periods with a growing and declining trend interchanged.

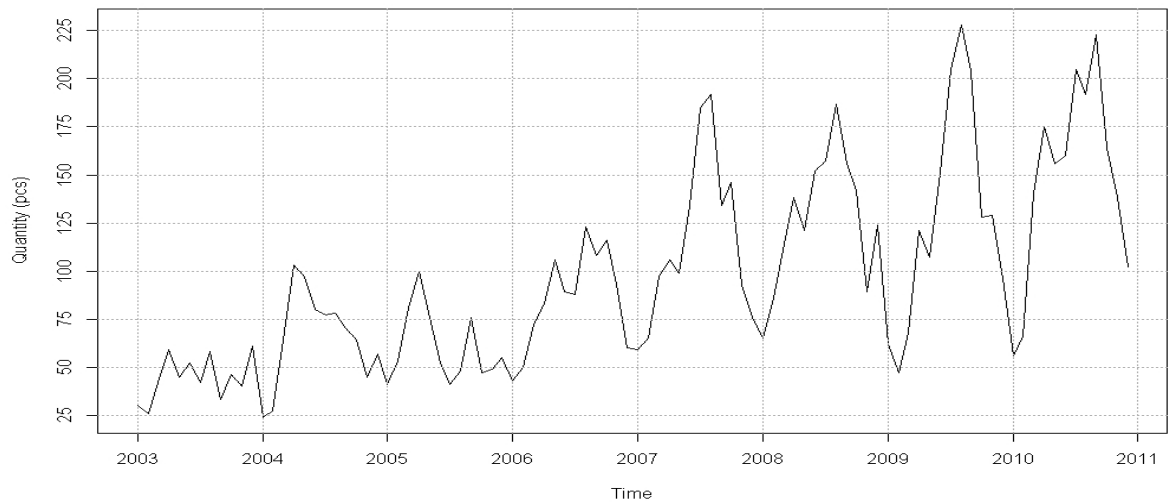


Fig. 3. The distribution of the number of warranty and post-warranty inspections and repairs of farm machines and vehicles in the years 2003-2010 [The author's own study]

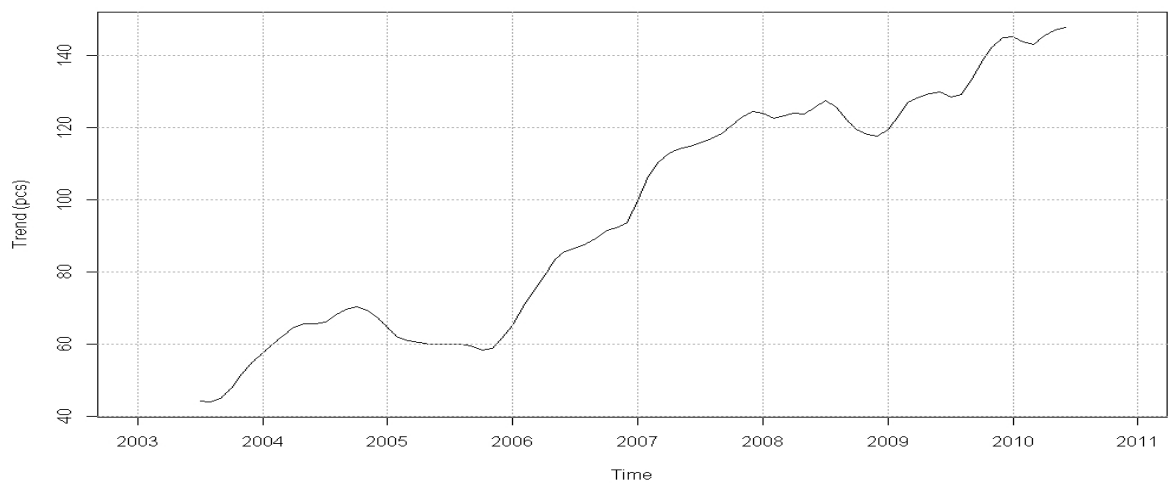


Fig. 4. The quantitative trend of the number of warranty and post-warranty repairs of farm machines and vehicles in the years 2003-2010 [The author's own study]

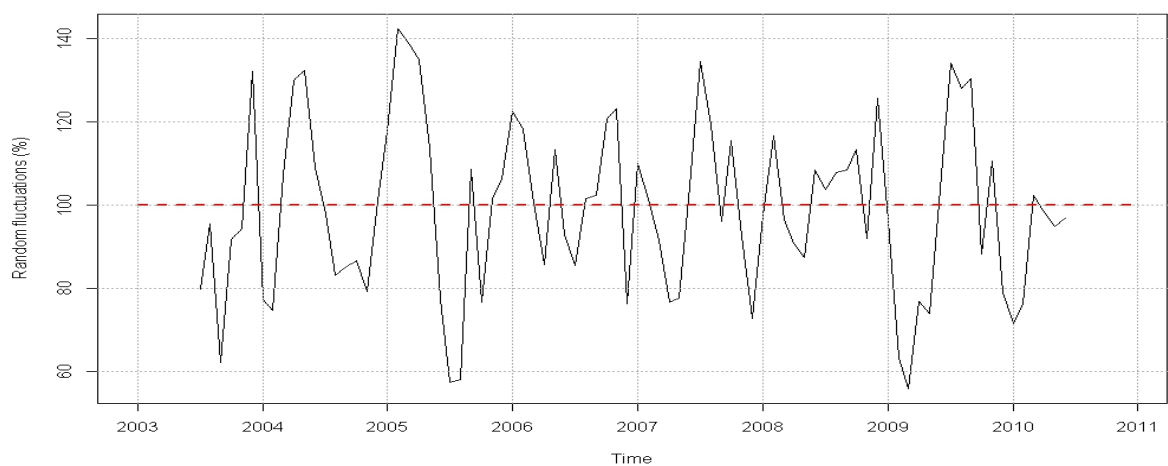


Fig. 5. Random fluctuations of the number of warranty and post-warranty inspections and repairs of farm machines and vehicles in the years 2003-2010 [The author's own study]

Random fluctuations selected from the time series of inspections and repairs are presented in Fig. 5. The changes in demand for the technical maintenance of farm vehicles and machines were of a dynamic nature and considerable differences in demand levels were observed in the surveyed periods. The variability of demand for the service work was caused by the changeable number of requests for particular types of services in the successive months and

years. The structure of random fluctuations in the surveyed years justifies a thesis on the unstable level of demand for the technical maintenance of farm vehicles and machines. The highest amplitude of the number of servicing work carried out was recorded in the years 2005 and 2009. Random changes in demand constituted a significant organisational problem in the management process of the service operation.

Adjusting for the trend as well as cyclical and random fluctuations made it possible to calculate the value of seasonal indexes for the servicing activities concerning farm vehicles and machines (Fig. 6).

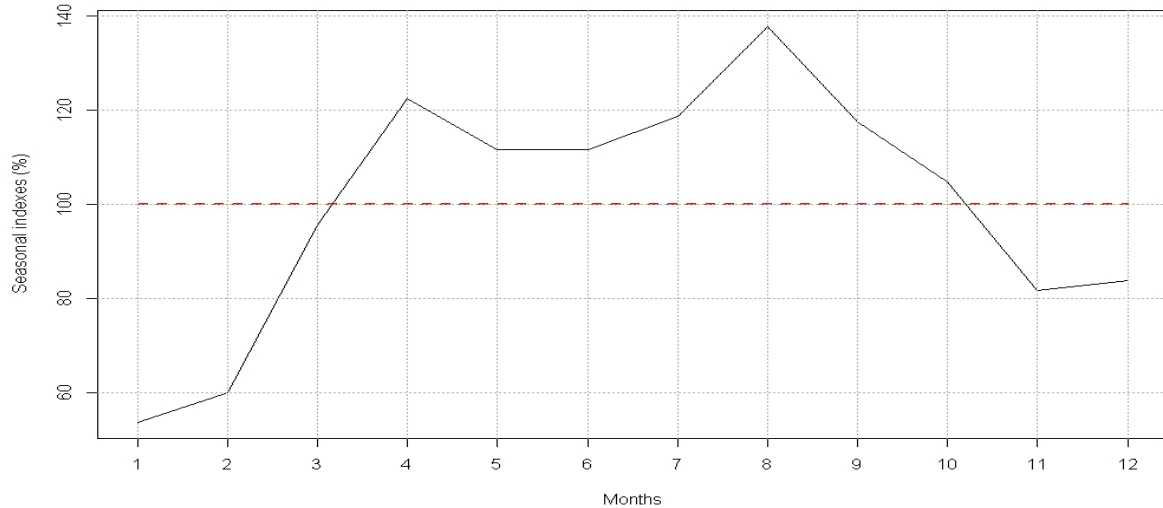


Fig. 6. The seasonal indexes of the number of warranty and post-warranty inspections and repairs of farm machines and vehicles in the years 2003-2010 [The author's own study]

As a result of seasonal fluctuations, in January, February and March the number of servicing activities was lower than the reference level by, respectively, 46.2%, 39.9% and 4.4%. Lowering the demand for the work of the service point, especially in the winter period, was a result of the lack of field agrotechnical procedures, and a less frequent use of vehicles and machines. Commencing spring field operations generated an increase in the orders submitted to the Service Department. The local maximum of demand occurred in April, when the seasonal index was higher than the reference level by 22.5%. In May and June the demand for servicing activities was equal and exceeded the average level by 11.6%. As a result of seasonal fluctuations connected with harvesting cereal and root vegetables crops as well as autumn field work, the indices in July, August, September and October amounted to, respectively, 18.7%, 37.8%, 17.7% and 4.8% above the reference level. In November and December, a drop in demand for inspections and repairs was observed, and seasonal indexes were lower than the average level by, respectively, 18.1% and 16.2% [13].

CONCLUSIONS

1. The high level of competition on the servicing market generates a number of actions modifying customer service in connection with carrying out inspections and repairs. Service employees having direct contact with the users of the products are obliged to support the servicing process with media aspects. Professionalism together with the ability to transfer information and provide explanations in the scope and form expected by the client builds trust and reinforces loyalty towards the company. Gaining and maintaining the users' trust depends on the effectiveness and timeliness of the technical maintenance activities. It is also important to fulfil the declarations and promises regarding the course and time needed for the completion of the servicing tasks. The condition of success is finding a compromise between areas relating to clients' expectations, the logistic possibilities of the distribution enterprise, and the organisational and technical efficiency of the service point.
2. Client satisfaction results from a number of actions which should be undertaken during the realisation of technical maintenance orders. Empathy of the service employees constitutes one of the most important conditions of servicing, assessed by clients as equally important as the time of service realisation and the declared period of work completion. An individual approach to clients' requirements makes it possible to find an optimum solution to the indicated problems. Effective implementation of inspections, current repairs and overhauls should also include the choice of methods ensuring the reduction of costs of the spare parts and materials used, and of the time of operation, simultaneously maintaining the quality standards required for technical maintenance.

3. Engineer and technical workers should have proper education in the field and undergo training to raise their qualifications. It is crucial to update the skills connected with maintenance, diagnostics and repair of subassemblies installed in farm vehicles and machines because now more advanced construction and technological solutions are applied during their production.
4. Inspections and repairs of farm vehicles and machines were conducted by the Service Department with a varying demand within all the surveyed years. In the six surveyed periods, the surveys confirmed an increase in the number of servicing activities by several to several dozen percent in a year-on-year comparison.
5. The trend identified during the statistical analysis of the number of servicing activities varied within the surveyed period. The periods with a long-term upward trend prevailed over the time when the trend was declining. The value and dynamics of the trend changes should be further analysed in order to determine long-term the demand for servicing activities.
6. The statistical analysis of the work carried out by the Service Department confirmed the presence of random fluctuations. The unstable demand for technical maintenance of farm vehicles and machines with high amplitude is unfavourable for the functioning of the service point. Random fluctuations constitute a factor with a destructive influence on logistic management of human and technical potential, and can lead to extending the waiting time and the completion of servicing activities.
7. The prepared distribution of values of seasonal indexes provides grounds for a hypothesis concerning the significant influence of the agrotechnical work and operations on cyclical changes in demand for the technical maintenance of farm vehicles and machines. As a result of seasonal fluctuations, a considerable reduction of demand for servicing inspections and repairs occurred in January, February, November and December, when no field work is carried out. Seasonal fluctuations also cause a local increase in demand for servicing activities during spring field work and cereal harvesting, as well as field work connected with harvesting root vegetables.

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Accepted for print: 31.12.2012