Organizational and technological compatibility of the technological processes of second and third line maintenance of KhTZ-3522 tractors

Roman Kyzminskyj[1], *Ruslan* Barabash[1]

[1]Lviv National Agrarian University, St. Vladimir the Great 1, 80381, Dubliany, Ukraine

Abstract. The work is devoted to systematic substantiation of productivity, production structure and specialization of service stations of KhTZ-3522 tractors. Based on the technical and economic comparative analysis of the results of the technological processes modeling of the second and third line maintenance of KhTZ-3522 tractors, the parametrical series of production structures of service stations both mono- and polytechnological specialization, which can work effectively in a wide range of the general annual program of orders, and in the conditions of seasonal fluctuations of orders for the maintenance of these tractors, are found. The results of calculations of the indicators system for organizational and technological compatibility of technological processes of the second and third line maintenance of KhTZ-3522 tractors in the joint technological flow are presented. The dependencies of these indicators on the total annual program of orders for service stations of different productivity are analyzed. According to the results of the analysis, the polytechnological specialization of such service stations is substantiated.

1 Introduction

Tractors of Kharkiv Tractor Plant (KhTZ) are among the most common in Ukraine. In addition to well-known brands such as KhTZ-150K-09 (drawbar category – 3,0), KhTZ began production of new tractors, in particular KhTZ-3510 (drawbar category – 0,9) and KhTZ-3522 (drawbar category – 1,4), which are intended mainly for small farms.

Efficient use of these new brands of tractors involves timely and qualitative maintenance. First (service interval – 250 hours), second (service interval – 500 hours) and third (service interval – 1000 hours) line maintenance are provided by the manufacturer for these tractors. The list of operations for each type of maintenance is determined by the manufacturer [1, 2]. The operations of each previous line maintenance are included in the following line maintenance. Real first line maintenance are performed by tractor drivers directly at the place of tractors operation. In order to perform operations of second line maintenance of KhTZ-3522 tractors, there is need to use 14 different types of special equipment and tools (r =14), and to perform operations of third line maintenance – 15 different types (r = 15). Therefore, qualified masters at stationary posts of service stations must carry out these complex types of maintenance [3, 4].

However, the technical service base for these new KhTZ tractor brands has not yet been created in Ukraine.

An effective performance of maintenance service on a long-term basis leads to developing loyalty of the client to the company [5]. Technical service is of primary importance in building the client's satisfaction. It should be performed by highly qualified staff and the logistic system of the service should be suited for effective realization of orders placed by users [6].

The substantiation of the program W_A, the performance Q_A, the production structure and the specialization of the technical service enterprises are complex system tasks [7], which involve the use of an iterative procedure for the solution of interdependent parametric and structural optimization tasks [8].

Regarding the technical service processes performed on stationary posts, the task of substantiating their parameters and structure was for the first time solved using the graph theory and schedules for the technological processes of the current repair of tractors [9], but the interdependence between all parameters and performance indicators of the technological process was not taken into account. The application of the iteration procedure has made it possible to eliminate this defect in relation to the tasks of determining the parameters and indicators of efficiency of the technological processes of maintenance of KhTZ tractors [10], as well as the substantiation of the production structure of the service stations of KhTZ tractors [11, 12].

The ground for the determination of specialization of selected production units of the technical service enterprises is organizational and technological

* Corresponding author: rkuzminsky@gmail.com

compatibility (OTC) of the processes performed there [13]. The property of the OTC is determined by the similarity of the construction design of the machines and the technology of the work, the flexibility of the equipment used, and also depends on the overall annual program of work (general program), and on the quantitative proportion of various processes (partial programs) in the general program. If for a certain value of a general program and a certain proportion of partial programs, the cost of implementing different processes in the joint flow is less than the cost of implementing the same processes separately, then it is considered to be OTC of these processes.

In the case of OTC of the different technological processes, a multidisciplinary or polytechnological specialization is appropriate.

For the quantitative assessment of the properties of the OTC, the system of indicators with a certain technical, technological and production content is used [14].

An assumption was made that any ratio of partial programs of orders for different types of technical maintenance in the total program of orders $W_{A\ \min}$ is equally probable. Then the coefficient of OTC α_W – is the probability of the occurrence of such ratio of partial programs for which the costs for different types of maintenance in the joint flow on SS of polytechnological specialization are less than the costs of implementing the same processes separately on different SSs of monotechnological specialization. Then also the coefficient level of OTC β_W – is the probability of obtaining for a considerable period of time T such a cost benefit from joining technological processes of different types of maintenance in the joint flow. If only such ratios of partial programs of orders for different types of technical maintenance in the total program of orders $W_{A\ \min}$ are taken into account, for which the OTC exists, then the coefficient relative level of OTC γ_W – identifies the ratio between the cost benefit from joining technological processes of different types of maintenance in the joint flow on SS of polytechnological specialization and the total costs for maintenance in the joint flow. The method [15] for calculating these indices has been developed in advance.

The objective of the work is to increase the efficiency of the technical service of the KhTZ-3522 tractors by way of substantiation of the specialization (mono- or polytechnological) of branded service stations of different capacity and production structure from the corresponding parametric series.

2 Methodology

According to the results of modeling of the technological processes of second and third line maintenance of KhTZ-3522 tractors using the theory of graphs and heuristic algorithms of the theory of schedules and analysis of the mutual dependencies between different parameters and performance indicators of these processes [12], the set of possible different variants of production structures of service stations, which provide the same annual Q_A. capacity, has been synthesized.

The feasibility and economic comparison of various possible options was made on the basis of the total expenditure for the entire annual maintenance program ΣZ. The total expenditure ΣZ included the costs determined by the production structure of the service station Z_{SS} (wages of workers, allowance for keeping and depreciation of equipment and industrial premises, payment for power electric etc.), and also the costs which are determined by the technology of performance Z_{lm} (costs for fuel, lubricants and other process materials etc.). The arrangement of the comparison results made it possible to form parametric series of service stations for KhTZ-3522 tractors (Table 1, 2) with different production structure and capacity of monotechnological specialization (for the performance of only second or only third line technical maintenance respectively). The optimal capacity for each maintenance item from the parametric series was determined by the criterion for minimizing specific costs ($C = \Sigma Z/Q_A) \rightarrow$ min.

3 Results and discussion

To the parametric series of service stations for the second line maintenance of KhTZ-3522 tractors (Table 1) five different variants of production structures have been included, that differ in the number of equipment of individual types (high-pressure jet cleaners Karcher K5 Compact K_{r1}, mobile machines Flexbimec-5903 for washing parts K_{r6} and universal devices C-230 for oiling K_{r7}) the number of stationary posts f, and, consequently, the production area. The list of all other types of required equipment for the second line maintenance of KhTZ-3522 tractors is determined by the technology of work [1, 2]. Since all other types of necessary equipment are intended to perform only one operation, the number of equipment of all other types K_r = 1 pcs.

The capacity of each variant of the production structure of the technical service station may vary within a sufficiently wide range, depending on the number of employees engaged, which enables the adaptation of service station performance to seasonal variations in the number of orders (Table 1, 2).

For example, the first variant of the production structure of the service stations for the second line maintenance of KhTZ-3522 tractors can provide maximum annual capacity Q_A = 896 orders per year, if the number of workers is u = 4 persons. If the number of workers is u = 1 person, then annual capacity will be only Q_A = 296 orders per year. For this production structure, optimal performance that meets the minimum specific costs is 799 orders per year, when three workers work (u = 3 persons). The second variant of the production structure of the service station for the second line maintenance of KhTZ-3522 tractors is characterized by an increase in the number of equipment (high-pressure jet washing machines Karcher K5 Compact K_{r1}= 4 pcs, mobile machines Flexbimec-5903 K_{r6} = 2 pcs and universal devices C-230 for filling oil K_{r7} = 2 pcs). This variant can provide maximum annual capacity Q_A =

=1040 orders per year, if the number of workers is $u = 8$ persons. For this production structure, optimal performance is a bit bigger and it is 877 orders per year, when three workers work ($u = 3$ persons).

The next three variants of the production structure of the service stations for the second line maintenance of KhTZ-3522 tractors are characterized by an increase in the number of posts f and working area respectively. Each next variant has a wider range of productivity changes by attracting a different number of workers. The optimal performance of each next variant is also higher than the previous one and it is achieved for an ever-greater number of workers.

To the parametric series of service stations for the third line maintenance of KhTZ-3522 tractors (Table 2) also includes five different variants of production structures. These variants are very similar to the corresponding variants of production structures of service stations for the second line maintenance of KhTZ-3522 tractors and differ only in the use of additional type of equipment ($r = 15$) – the testing bench of tractor electrical equipment group SKIF-1-03. However, it should be noted that for similar variants of the production structure, the maximum and optimal values of annual capacity of service stations for the third line maintenance of KhTZ-3522 tractors are significantly lower than the corresponding values of service stations for the second line maintenance.

Table 1. The parametric series of service stations with different production structure and capacity for the second line maintenance of KhTZ-3522 tractors.

№of SS	**Annual capacity Q_A, orders**	**Amount of equipment and tools*, pcs.**			**Number of posts *f*, units**	**Number of workers *u*, persons**	**Economic indicators**			
		K_{r1}	K_{r6}	K_{r7}			Z_{SS}, UAH	Z_{l-m}, UAH	ΣZ, UAH	*C*, UAH
I	296	1	1	1	1	1	117475	1844719	1962194	6629,03
	562					2	165475	3502474	3667949	6526,6
	799^{opt}					3^{opt}	213475	4979496	5192971	6499,34
	896					4	261475	5584015	5845490	6523,98
II	296	4	2	2	1	1	126168	1844719	1970887	6658,4
	593					2	174168	3695671	3869839	6525,87
	877^{opt}					3^{opt}	222168	5465604	5687772	6485,49
	1040					4	270168	6481446	6751614	6491,94
III	296	4	2	2	2	1	138516	1844719	1983236	6700,12
	605					2	186516	3770457	3956973	6540,45
	903					3	234516	5627640	5862157	6491,87
	1217					4	282516	7584539	7867055	6464,3
	1522^{opt}					5^{opt}	330516	9485348	9815864	6449,32
	1739					6	378516	10837726	11216243	6449,82
	1916					7	426516	11940819	12367335	6454,77
	2049					8	474516	12769696	13244212	6463,74
IV	296	4	2	2	3	1	153975	1844719	1998695	6752,35
	614					2	201975	3826546	4028522	6561,11
	915					3	249975	5702426	5952402	6505,36
	1217					4	297975	7584539	7882514	6477
	1510					5	345975	9410562	9756537	6461,28
	1784					6	393975	11118173	11512149	6453
	2049					7	441975	12769696	13211671	6447,86
	2300^{opt}					8^{opt}	489975	14333968	14823943	6445,19
	2493					9	537975	15536775	16074750	6447,95
	2555					10	585975	15923169	16509144	6461,5
V	296	4	2	2	4	1	176542	1844719	2021261	6828,58
	616					2	224542	3839011	4063552	6596,68
	920					3	272542	5733587	6006129	6528,4
	1224					4	320542	7628164	7948706	6494,04
	1522					5	368542	9485348	9853889	6474,3
	1815					6	416542	11311370	11727912	6461,66
	2090					7	464542	13025214	13489756	6454,43
	2379					8	512542	14826309	15338850	6447,6
	2620^{opt}					9^{opt}	560542	16328259	16888801	6446,11
	2797					10	608542	17431352	18039893	6449,73
	3000					11	656542	18696480	19353022	6451,01
	3136					12	704542	19544054	20248596	6456,82
	3234					13	752542	20154805	20907347	6464,86
	3338					14	800542	20802950	21603492	6471,99

*Amount of equipment and tools: $K_{r2} = K_{r3} = K_{r4} = K_{r5} = K_{r8} = K_{r9} = \ldots = K_{r14} = 1$ pcs.

Table 2. The parametric series of service stations with different production structure and capacity for the third line maintenance of KhTZ-3522 tractors

№ of SS	Annual capacity Q_A, orders	Amount of equipment and tools*, pcs.			Number of posts *f*, units	Number of workers *u*, persons	Economic indicators			
		K_{r1}	K_{r6}	K_{r7}			Z_{SS}, UAH	Z_{l-m}, UAH	ΣZ, UAH	*C*, UAH
I	229	1	1	1	1	1	122966	1822650	1945616	8496,14
	440					2	170966	3502035	3673001	8347,73
	589 opt					3 opt	218966	4687951	4906917	8330,93
	625					4	266966	4974481	5241448	8386,32
II	229	4	2	2	1	1	131659	1822650	1954309	8534,1
	458					2	179659	3645300	3824959	8351,44
	638 opt					3 opt	227659	5077951	5305610	8316
	694					4	275659	5523664	5799323	8356,37
III	229	4	2	2	2	1	144008	1822650	1966658	8588,02
	464					2	192008	3693055	3885063	8372,98
	696					3	240008	5539582	5779590	8304,01
	936					4	288008	7449783	7737791	8266,87
	1118 opt					5 opt	336008	8898352	9234360	8259,71
	1254					6	384008	9980799	10364807	8265,4
	1335					7	432008	10625492	11057500	8282,77
	1408					8	480008	11206511	11686519	8300,08
IV	229	4	2	2	3	1	159467	1822650	1982117	8655,53
	471					2	207467	3748769	3956236	8399,65
	704					3	255467	5603256	5858722	8322,05
	932					4	303467	7417946	7721413	8284,78
	1156					5	351467	9200801	9552267	8263,21
	1344					6	399467	10697125	11096591	8256,39
	1533 opt					7 opt	447467	12201408	12648874	8251,06
	1656					8	495467	13180386	13675852	8258,36
	1725					9	543467	13729568	14273035	8274,22
	1815					10	591467	14445894	15037360	8285,05
V	229	4	2	2	4	1	182033	1822650	2004683	8754,07
	472					2	230033	3756728	3986761	8446,53
	706					3	278033	5619174	5897207	8352,98
	936					4	326033	7449783	7775816	8307,5
	1169					5	374033	9304270	9678303	8279,13
	1389					6	422033	11055287	11477320	8263,01
	1580					7	470033	12575489	13045522	8256,66
	1739					8	518033	13840997	14359030	8257,06
	1934 opt					9 opt	566033	15393035	15959068	8251,84
	2070					10	614033	16475482	17089515	8255,8
	2178					11	662033	17335072	17997105	8263,13
	2250					12	710033	17908133	18618165	8274,74
	2325					13	758033	18505070	19263103	8285,21
	2379					14	806033	18934865	19740898	8297,98

* Amount of equipment and tools: $K_{r2} = K_{r3} = K_{r4} = K_{r5} = K_{r8} = K_{r9} = \ldots = K_{r14} = K_{r15} = 1$ pcs.

For example, the maximum annual capacity of the third variant of the production structure of the service station for the second line maintenance of KhTZ-3522 tractors is $Q_A = 2049$ orders per year, and the maximum annual capacity of the third variant of the production structure of the service station for the third line maintenance of KhTZ-3522 tractors is only $Q_A = 1408$ orders per year. This significant difference is explained by the greater labor-intensive characteristic of the technological processes of the third line maintenance.

Because all operations of the second line maintenance of KhTZ-3522 tractors are also performed during the third line maintenance of these tractors, therefore the parametric series of service stations for the third line maintenance corresponds to the parametric series of the polytechnological specialization service stations of KhTZ-3522 tractors, where one can perform these two different types of technical maintenance in the joint technological flow (Table 3).

It should be noted, that the capacity of service stations for maintenance of KhTZ-3522 tractors of the polytechnological specialization depends on the ratio of orders for different types of maintenance: maximum capacity $Q_{A\ max}$ is reached, when all orders will be executed for only second line maintenance, but minimal capacity $Q_{A\ min}$, when all orders will be for the third line maintenance only (Table 3).

Table 3. The results of calculation of indexes of organizational and technological compatibility (OTC) of second and third line maintenance for service stations with different production structure and capacity from parametric series.

№of SS	Annual capacity Q_A, orders		Amount of equipment and tools*, pcs.			Number of posts *f*, units	Number of workers *u*, persons	Indexes of organizational and technological compatibility (OTC)		
	$Q_{A\max}$ for second line maintenance	$Q_{A\min}$ for thirdline maintenance	K_{r1}	K_{r6}	K_{r7}			α	β	γ
I	296	229	1	1	1	1	1	1	1	0,9553
	562	440					2	1	1	0,5679
	799	589					3	1	1	0,3978
	896	625					4	1	1	0,235
	for first service station in general							**1**	**1**	**0,5865**
II	296	229	4	2	2	1	1	1	1	0,8262
	593	458					2	1	1	0,5022
	877	638					3	1	1	0,3809
	1040	694					4	1	1	0,2612
	for second service station in general							**1**	**1**	**0,5094**
III	296	229	4	2	2	2	1	1	1	0,6696
	605	464					2	1	1	0,4106
	903	696					3	1	1	0,3232
	1217	936					4	1	1	0,2915
	1522	1118					5	1	1	0,2704
	1739	1254					6	1	1	0,2149
	1916	1335					7	1	1	0,1538
	2049	1408					8	0,9957	0,9989	0,084
	for third service station in general							**0,9998**	**0,9999**	**0,2967**
IV	296	229	4	2	2	3	1	1	1	0,5078
	614	471					2	1	1	0,3077
	915	704					3	1	1	0,2507
	1217	932					4	1	1	0,229
	1510	1156					5	1	1	0,2113
	1784	1344					6	1	1	0,1902
	2049	1533					7	1	1	0,1666
	2300	1656					8	1	1	0,1474
	2493	1725					9	1	1	0,1082
	2555	1815					10	0,9183	0,9614	0,046
	for fourth service station in general							**0,9959**	**0,9992**	**0,2065**
V	296	229	4	2	2	4	1	1	1	0,3209
	616	472					2	1	1	0,1798
	920	706					3	1	1	0,1502
	1224	936					4	1	1	0,1465
	1522	1169					5	1	1	0,1422
	1815	1389					6	1	1	0,1373
	2090	1580					7	1	1	0,1307
	2379	1739					8	1	1	0,1235
	2620	1934					9	0,9969	0,9997	0,1067
	2797	2070					10	0,9986	0,9999	0,0916
	3000	2178					11	0,9920	0,9998	0,0728
	3136	2250					12	0,9078	0,9685	0,0445
	3234	2325					13	0,4923	0,5841	0,0228
	3338	2379					14	0,2595	0,283	0,0144
	for fifth service station in general							**0,9636**	**0,9789**	**0,1191**

The system of OTC indicators includes coefficients of OTC α_W, level of OTC β_W and relative level of OTC γ_W, that are calculated for a particular value of the annual program $W_{A\ \min}$, provided, that any ratio of partial programs of orders for different types of technical maintenance in the total program of orders $W_{A\ \min}$ is equally probable.

Dependencies of OTC indicators of the technological processes of second and third line maintenance of tractors KhTZ-3522 in the joint technological flow on annual program $W_{A\ \min}$ (by the number of orders for third line maintenance), received for the fifth variant of the production structure of the service station of the polytechnological specialization (Table 3), are shown in Figures 1-3.

These dependencies are discontinuous functions, intervals of continuity which coincide with the intervals of programs for the fifth variant of the production structure of the service station of the polytechnological specialization, where the number of workers u remains unchanged (Figures 1–3).

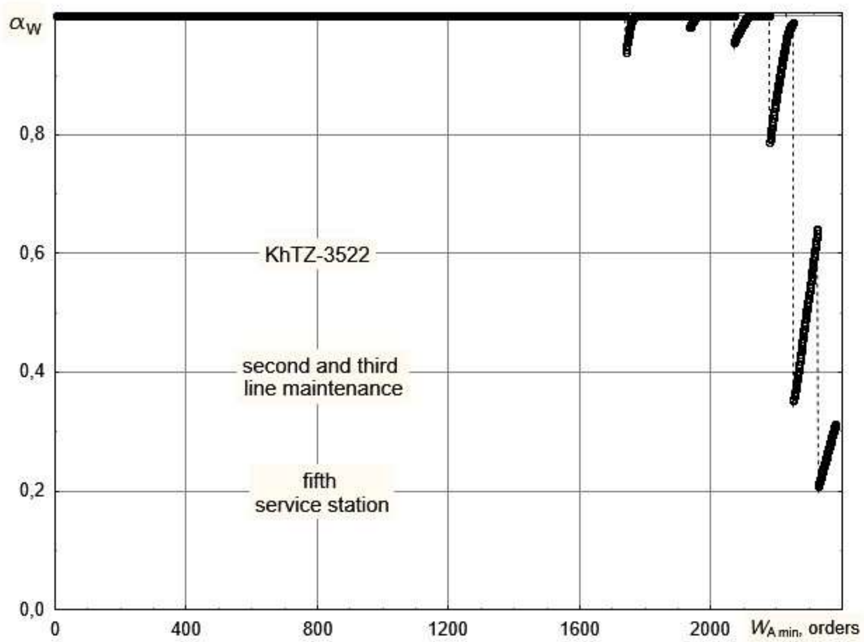

Fig. 1. Dependence of the coefficient of OTC α_W of second and third line maintenance of KhTZ-3522 tractors on the annual number of third line maintenance orders $W_{A\ \min}$ for fifth service station.

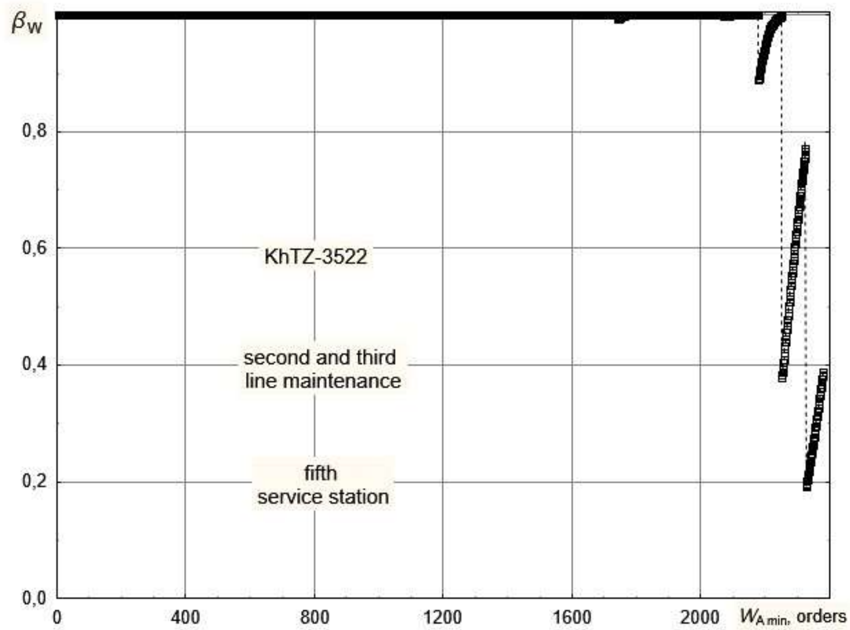

Fig. 2. Dependence of the coefficient of level of OTC β_W of second and third line maintenance of KhTZ-3522 tractors on the annual number of third line maintenance orders $W_{A\ \min}$ for fifth service station.

As you can see (Figures 1–3) on the intervals of continuity, with the total annual program $W_{A\min}$ increasing, the values of the coefficient of OTC α_W and the coefficient of the level of OTC β_W remain constant, provided that a complete OTC of technological processes of various types of maintenance in the joint technological flow is in evidence ($\alpha_W = \beta_W = 1$), or increases nonlinearly.

When the program $W_{A\ \min}$ increases, the values of the coefficient of the relative level of OTCγ_W on the intervals of continuity remain constant or non-linearly increase even if a complete OTC of technological processes of various types of maintenance of tractors KhTZ-3522 ($\alpha_W = \beta_W = 1$) in a joint flow is in evidence.

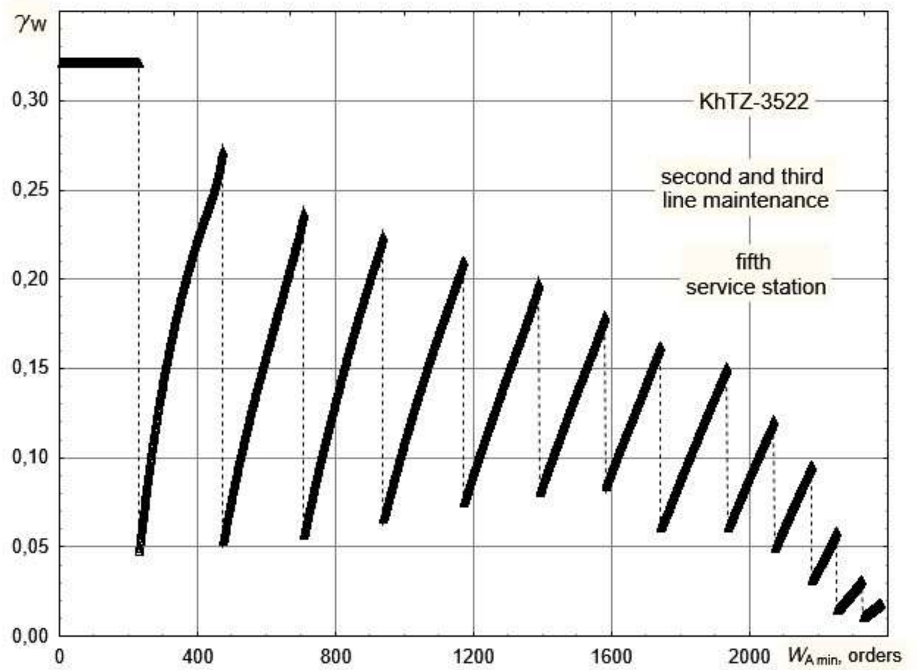

Fig. 3. Dependence of the coefficient of relative level of OTC γ_W of second and third line maintenance of KhTZ-3522 tractors on the annual number of third line maintenance orders $W_{A\ \min}$ for fifth service station.

The analysis of the results of calculating the values of OTC indicators of the technological processes of second and third line maintenance for service stations with different production structure and capacity from parametric series (Table 3), which was conducted under the additional condition that any values of the annual program $W_{A\ \min}$ (by the annual number of third line maintenance orders), that are possible for a constant number of workers u = const, are equally probable, allowed to reveal certain regularities.

Firstly, for each variant of the production structure of the service stations, with an increase in the number of workers, the values of OTC indexes do not increase. For example, for the third variant of the production structure of the service station, where the technological processes of the second and third line maintenance of tractors KhTZ-3522 are executed in the joint technological flow by two workers (u=2 persons) – $\alpha = \beta = 1,0$ and $\gamma = 0,4106$; and when u = 8 persons – $\alpha = 0,9957$, $\beta = 0,9989$, $\gamma = 0,084$ (Table 3).

Secondly, for service stations with a more complex production structure and higher capacity, the values of the OTC indicators are lower. For example, if for the third variant of the production structure of the service station in general $\alpha = 0,9998$, $\beta = 0,9999$ and $\gamma = 0,2967$, then for fifth variant of the production structure of the service station in general $\alpha = 0,9636$, $\beta = 0,9789$ and $\gamma = 0,1191$ (Table 3).

Thirdly, the most sensitive to the growth of the overall annual program of orders is the coefficient of the relative level of OTCγ.

At the same time, the obtained values of OTC indicators of the technological processes of second and third line maintenance in the joint flow for all five variants of production structures of service stations for tractors KhTZ-3522 designate the expediency of their polytechnological specialization.

4 Conclusions

1. The formed parametric series of production facilities of service stations for maintenance of KhTZ-3522 tractors both mono- and polytechnological specialization (Table 1-3) are the basis for the choice of the effective design solutions with following aspects to be taken into account: firstly, the forecast of annual changes in the total number of maintenance orders due to the changes in the number of these tractors in the service area, and, secondly, the prediction of seasonal fluctuations in the

flow of orders due to the objective variation of use of these tractors in agriculture.

2. The obtained values of OTC of the technological processes of second and third line maintenance in the joint technological flow for all five variants of production structures of the service stations for maintenance of KhTZ-3522 tractors give reasons for the polytechnological specialization of such items.

References

1. *Process flow charts of pre-sales service and maintenance of KhTZ-3512, KhTZ-3522 tractors*, Kharkov Tractor Plant named after S. Ordzhonikidze, p. 80 (2014)
2. *Tractor KhTZ–3512. Operating instructions. 3512.00.001,* Kharkov Tractor Plant named after S. Ordzhonikidze, p. 46 (2014)
3. M.V. Molodyk, A.M. Morgun, L.I. Shapoval at all, *Organizational forms of technical service and forecast of their development in market conditions of management in the agroindustrial complex of Ukraine. Recommendations*, National Scientific Center «Institute of Mechanization and Electrification of Agriculture», p. 170 (2001)
4. O.V. Sydorchuk, S.R. Senchuk, O.V. Kukharuk, *Scientific bases of engineering management of technical service of crop farming*, *Monograph*, p. 172 (2001)
5. A. Bailey, N. Williams, M. Palmer, R. Geering, AGRICULTURAL SYSTEMS, *The farmer as service provider: the demand for agricultural commodities and equine services*, **3** (66), 191-204 (2000)
6. S. Juściński, W. Piekarski, Maintenance and Reliability, *The farm vehicles operation in the aspect of the structure of demand for maintenance inspections,* **1** (45), 59-68 (2010)
7. O.D. Semkovych, R.D. Kuzminskyj, V.E. Chukhrai, M.S. Oliskevych, News of Agrarian Sciences, *Formation and development of the theory of repair and recovery processes,* **Special issue, September**, 90–96 (2001)
8. R.D. Kuzminskyj, Bulletin of Lviv State Agrarian University: Agroengineering research, *Structure, parameters and efficiency of technological processes of repair*, **9**, 50–60 (2005)
9. V.O. Tymochko. Dis. Cand. Tech. Sciences: 05.20.03, *Effective production structure of technological stations of current repairs of tractors of classes 0,9 and 1,4*, p. 241 (1994)
10. R.D. Kuzminskyj, R.I. Barabash, Bulletin of Lviv State Agrarian University: Agroengineering research, *Parameters and performance indicators of technological processes of technical service performed on stationary posts*, **10**, 66 – 73 (2006)
11. O.V. Sydorchuk, R.D. Kuzminskyj, R.I. Barabash, M.A. Mykhajluk, Bulletin of Lviv National Agrarian University: Agroengineering research, *Justification of production structure of service stations for maintenance of KhTZ tractors*, **17**, 54–64 (2013)
12. R.D. Kuzminskyj, R.I. Barabash, Scientific discussion: Issues of technical sciences, *The results of modeling of technological processes of maintenance of KhTZ–3522 tractors*, **4** (25), 97–107 (2015)
13. R.D. Kuzminskyj, Agricultural machines. – Collection of scientific articles, *An organizational and technological compatibility of different objects repair processes in joint technological flow as the basis of formation of thefirm technical service*, **14**, 114–124 (2006)
14. R.D. Kuzminskyj, Theory and practice of development of the agro-industrial complex: Materials of the international scientific and practical forum, *An improvement of the indicators system of organizational and technological compatibility of different objects repair processes in joint technological flow*, **2**, 354–359 (2006).
15. R.D. Kuzminskyj, I.G. Stukalec. Ecological, technological and socio-economic aspects of the use of material and technical base of the agro-industrial complex: Materials of the international scientific and practical forum. *Calculation of the indicators of organizational and technological compatibility of different objects repair processes for single tact value*, 406–409 (2008)