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# RESEARCH OF INFLUENCE OF SPECIALIZATION LEVEL OF PERMANENT REPAIR POSTS ON EFFICIENCY OF AUTOSERVICE ENTERPRISES FUNCTIONING

BY

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**Abstract.** There has been developed a schematic diagram of mass service systems with regard to the auto service center enterprises. There has been considered the indicators of specialization at various organizational forms of car repairs at the car service enterprises. There has been developed the generalized block diagram for the functioning algorithm of the car service enterprise.

**Key words:** car service enterprise, specialization, system of mass service, specialized repair station, universal station, operation algorithm.

## 1. Introduction

Operation of the park of cars which is available on the territory of Ukraine inevitably causes the need in perfect and flexible system of car service which is poorly developed in the country. The system of car service has previously been presented by the car service centers, which functioned in towns and cities and sometimes - in the regional centers. Today, under the conditions of the market relations and free competition, the network of the car service enterprises extends, though the profitability of many of them remains low, some of them close down due to wrong choice of specialization of their activity. The

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enterprises are formed spontaneously, the type of their activity is based upon the opinion of the manager himself or a group of people, their activity has no scientific substantiation and the statistic analysis of needs in these or those types of works. Defects and failure of the car may occur with one or several units simultaneously. If the car service enterprise runs the universal repair stations, it often has to switch between the different types of works within the working day to perform different types of operations. It also makes the workers, who have different specialities, to transfer from one repair station to the other etc, moving different equipment and appliances. Tooling up the repair stations with the full set of technological equipment, which may a priory be seldom used is the only way to overcome the above problem. In most cases, however, there fail one unit or the group of the homogeneous as for the design unites and it would be appropriate to specialize the repair stations in the repair zones, adjusting them to the execution of the homogeneous repair operations.

The issue of the efficiency in using the specialised car repair stations had been considered in many works. The paper (Pavlenko, 1969) uses the criteria for a minimum cost of works execution for the determination of place of repair (on the universal or specialized repair station). It suggests to perform the repair works of 48% of the input orders flow on the specialized repair station. The other 52% of repair works are performed on the universal repair stations. In paper (Dokunihin, 1983) it is suggested to determine the expedient correlations between the specialized and the universal operations, performed during the car repair, in comparison to the labor costs. It is necessary to determine the original approach to researching the issue of car repair stations specialization. The works with lower labor intensity and much time for rendering services must be performed on the universal repair station and the works with higher labor intensity must be transferred to the specialized repair station. Papers (Luik, 1976; Galushko, 1978) consider the issues of improving the maintenance of the building machinery by the specialized and the universal posts. The authors consider the maximum losses from the downtime of the building machinery and the repair stations as the criteria of optimal variant of performing the services by the repair stations.

There are the general shortcomings in researching the improvement of repair organization of the auto transport facilities on the base of full or partial specialization of the enterprise (Bidniak, 2006; Bilichenko, 2004):

− During the consideration of the repair works it is not taken into account neither is researched the existence of the range of varieties of its forms relating to specialized and universal repair stations;

− There has not been developed an adequate mathematical model for the functioning of the efficient system for car repair, which takes into account the distribution of the orders flow density;

− The following parameters of the system repair organization, such as the composition and structure of the servicing elements, sequence in distribution

the orders for universal and specialized repair stations remain the unexamined from the scientific point of view.

## 2. Selection of the Specialization Level of Repair Station

The organizational system of car service enterprise is a complex network of queuing systems, the operation of which is characterized by the following key parameters: quantitative and qualitative structure of the incoming flow orders; parameter of the flow of the vehicles recovery, the structure and structure of the repair area etc. The main purpose of functioning of auto service companies, service stations and repair shops – is a full satisfaction of orders for repairs, and getting maximum profit for the enterprises.

Structure of a queuing system for auto service company includes the following main elements (Fig. 1): the input stream of cars; stream of cars serviced; queue of cars waiting to repair, loading of the repair stations, down time of the repair station and the output stream of cars.

The determination of the flow of the cars for the repair is one of the most important tasks for the following assessment of organizational and technological solutions.

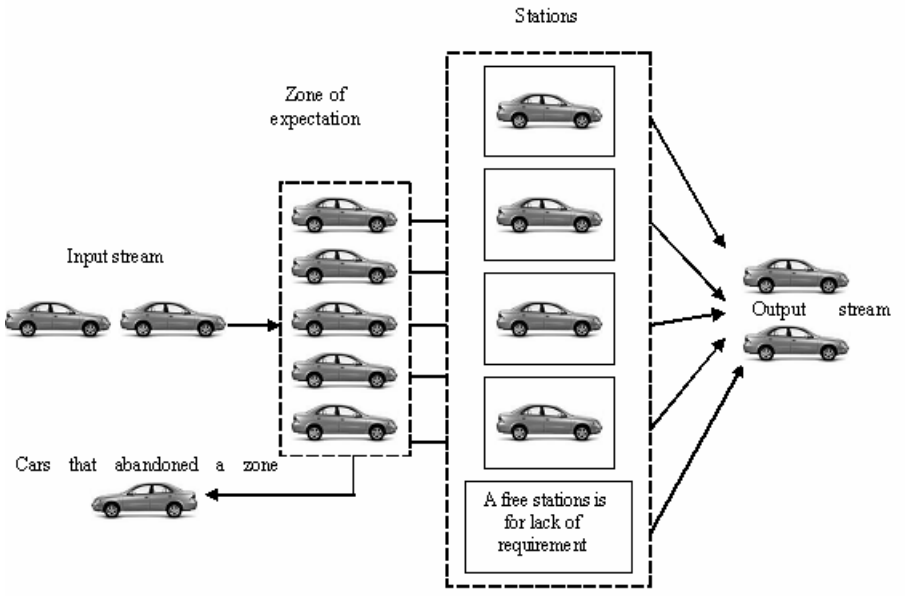


Fig. 1 − A schematic diagram of a queuing system with regard to enterprise service center.

The object of study of this work involves the examination of enterprise service center, close to the model that is in a certain area of road transport

operation. Technical condition and the first car that comes with a request for repair, is determined by some fault space P (N). For troubleshooting, occurring at the *i*-th vehicle required certain amount of time $t_i$ and money $z_i$ at market prices for repairs. In its turn, the cash costs can be represented as part of the cost of the system, the performance of the m-th impact - $S_e$ (salaries of employees, overhead, taxes, etc.), costs related directly to the implementation of technical influences blower SB (costs of idle positions, workers and equipment costs because of underloading of the stations, etc.) costs include other costs - $S_n$ (operating costs, capital investments, etc.).

Each *j*-th appearance of influence on the repair and the first car is characterized by a labor intensive works $t_m$. The effectiveness of the company is determined by the obtained gain, which is the difference between the income and the expenses:

$$P = D - S_{\Sigma} \tag{1}$$

where $D$ – is a profit for the period (year, quarter, month); $S_{\Sigma}$ - is the total expenses, deductions and losses that result from operation of the enterprise.

Equal time, monetary costs and income from certain types of repairs for all other things being equal depend on the form of the work, the level and degree of specialization share of the repair station. The set of rational means restorative influences concluded in the P (VI) space in the experimental list views work makes this P (phi)space. The P (phi) space is the optimal form of organization conducting research on car repairs maintenance positions in a market economy and free competition among auto service companies for providing services.

In the study of effective forms of car repairs in the auto service business research specialization of activities essential to the dissertation PCB, taking into account the specialized perform a specific share of work on the whole list, and is characterized by the following expression:

$$K_{SP} = \frac{\sum_{i=1}^{\mu} Tp_{SPi}}{\sum_{i=1}^{\mu} Tp_i} \tag{2}$$

where the $\sum_{i=1}^{\mu} Tp_{SPi}$ − is the total volume of work performed in specialized positions in μ repair occupations; $\sum_{i=1}^{\mu} Tp_i$ − is total volume of work based on universal and specialized positions.

Specialty repair auto service positions will enable the company to implement fully the incoming flow requirements for certain type of work on special repair post. A specialized works post is provided by appropriate specialized damage control equipment that will use modern technological processes and dramatically reduce the complexity of the work, as it provides highly skilled personnel.

Universal form of organization with partial specialization involves the establishment of a universal repair of fasts diagnostic complex in a special post. Implement appropriate specialized post in maximum proximity to each universal post, share their work time diagnosis post takes only on works that define the technical condition of the car (in the future, this car comes with one universal duties), and other times - carries in fully in their specialization.

The repair posts organization is also estimated by the breadth of their specialization, conditional on the number of technological homogeneous types of work. This indicator shows the breadth of the services' range which are provided to fast a repair. For example, a specialized section on car repairs with fault on the engine operation can be performed in such occupations as: gearbox and clutch, cooling system, power supply system, ignition system and speedometric equipment. In this case, the breadth of specialization NSP will is equal to the fate of specialization.

A general indicator of the first two is a composite index of specialization which is defined by:

$$K_{SP.K.} = \frac{K_{SP}}{H_{SP}} = \frac{\sum_{i=1}^{\mu} Tp_{SPi}}{\sum_{i=1}^{\mu} Tp_i \cdot H_{SP}} \tag{3}$$

The minimum value of the coefficient of PCB = 0 inherent universal form of production, all types of work performed on the universal positions. Value partially relevant the specialized organization form. Thus some of the work is done in a dedicated diagnosis post. The rest of the work is distributed between this post and other posts versatile. Value of CAE = 0.5 corresponds identically distributed complexity of work (with a variety of service requirements) between universal and specialized posts. This coefficient corresponds to the degree of specialization of the mixed form of repair work on auto service company. Increasing values of PCB corresponds to greater specialization particle positions. For example, PCB = (0.5 ... 1) corresponds to a specialized form of partial repair universal positions.

With this organization the universal post plays the role of "a damper" between the coming orders and existing types of specialized positions. With a specialized form of PCB = 1 in this case all the posts of repair are focused on

their specialization in certain types of work. For example, a special post on the car chassis, the post specialized on repairing the bodies and cabs, diagnosis post, and others.

Latitude specialization narrows with increasing degree of specialization ratio - increasing of the proportion of specialized posts. Increase your value and a composite index of specialization with increasing number of specialized posts on auto service company.

The task of selecting the five above-mentioned forms of car repairs is to define the options for management of manufacturing activity in the manager authority prior input. Implementation of management options on the calculated optimal organization represents the basis of the study. To solve this problem is required the group to identify the factors that most significantly affect the experimental process, to choose the optimization criterion, followed by its formalization.

**Table 1**

*The Unification of the Values of Specialization Factors in a Variety of Organizational Forms of Care Repair on Car Service Centers*

| Indeces | Organization forms | | | | |
|---|---|---|---|---|---|
| | Universal | Universal, partly specialised | Mixed | Specialized, partly universalized | Specialized |
| $K_{SP}$ | 0 | (0...0.5) | 0.5 | (0.5...1) | 1 |
| $H_{SP}$ | 12 | 1-5 | 1-4 | 1-3 | 1-3 |
| $K_{SP.K.}$ | 0 | 0.01-0.5 | 0.0125-0.5 | 0.0167-0.5 | 0.33-1 |

The formalization of the task on the determination of a reasonable level of specialization in manufacturing stations may be reduced to the following:

− the enterprise has a certain number of stations (universal and specialized) which determine their handling capacity depending on enterprise capacity;

− depending on the location of the enterprise, the operation conditions, technical state and the age of the rolling stock, operated in a certain area, there will be formed the input flow of orders on different types of works;

− the main indices of the performance of work by the enterprise is the time spent on the execution of works, the losses of the enterprise caused by service denial due to the overloading of the repair stations, as well as losses caused by the down time of the stations;

− organizing of carrying out of works requires an adequate variant of administration that will satisfy the requirements on service taking into account the rational usage of the up-to-date information on enterprise's functionality, enabling to get maximum income.

Thus, we assume that there is a system for the completion of the applications for maintenance and repair, the productivity of which $\gamma(t)$ is a variable value and depends on time. It is known that the input flow of requirements is a time function and is of random character with parameter $\mu = \gamma(t)$. The system control process should be organized in a way to get the repair zone function with maximum efficiency in accordance with the accepted optimality criterion $U$ on any time moment $t$ in the process of acceptance of previous information on the character of input flow and possibilities of the repair zone. In other words, it is necessary to find the correspondence between $\gamma(t)$ and $\mu$, with which function $U$ should have the maximum.

The system of automobile repair is known to be a closed system of mass service with the Poisson law of changing the input flow of requirements presenting the daily, weekly and annual nonstationarity.

The developed system uses the algorithm which allows to present the real process of car service center functioning.

The model is structurally based upon the processing of input previous information on real manufacturing processes of functioning the enterprise, accounting for the accepted strategy for service organization and automobile repair, done by technical service.

It is composed of number of subprograms (modules), aimed at generation of the random numbers as for the set law of distribution, formation of output data in tables, re-recording data files etc.

The peculiarity of an algorithm implies for the stations to be formed upon the questionnaires, considering the reliability of maintenance equipment and high quality of the personnel. This stipulates for the impossibility in creating the "strong" and "weak" universal and specialized stations.

The input data for the program is the set of variables and information array, aimed at accounting for necessary information during the organization of production station.

Taking into the account the contemporary terms of business, the model stipulates for the reflection of all internal and external processes, which take place in the under research object as well as in its environment.

The simulated algorithm for the functioning the organizational process of maintenance and repair of the automobile within the automobile operating company had been developed accounting for different levels in the specialization of production stations with the realization of the active variant of controlling over the production organization and is built on the base of system analysis of initial information on the input flow of the requirements.

The algorithm of formation of the production stations is developed accounting for two main principles.

1. The creation of the specialized station shall be conducted following the types of works, which are currently in steady demand. So, if the number of

input requirements on some works exceeds the possibility for them to be attended by the enterprise, there should be the research carried out aimed at the creation of the specialized station for this kind of work.

2. It is necessary to account the down time of the specialized post due to the delay in the order to come, since the bigger it is – the higher the losses of the enterprise. The realization of this condition required the development of the methodic and an algorithm for the system optimization with some parameters. For this case it had been accounted by three factors, which were determined as average pre year of the enterprise's operation. They are:

− ratio of down time of the station to the duration of the shift $K_{ПР}$;

− time for the attending the order $T_{ОБ}$, (hour);

− income, received in the result of the attending one order $П_{Ti}$, (Uhr).

The optimization of the system had been carried out following the principles of reflecting the parameters as the geometric configurations. According to this principle, on the axes *X* there shall be fixed the intervals, the length of which is proportional to the accepted weigh coefficient $П_i$ for each factor. Coefficient $П_i$ presents the specific weigh and the value of the *i*-th factor in their general volume and shall be determined by the formula:

$$П_i = \frac{P_i}{\sum_{i=1}^{m} P_i} \tag{4}$$

where $P_i$ – *i*-th factor of the efficiency in the system organization; *m* – number of accepted factors.

The following condition has to execute:

$$П_1 + П_2 + П_3 + ... + П_m = 1 \tag{5}$$

Configuration and the sizes of the received configurations depends on the size of the corresponding factor and its specific weigh in the system. Further on we will present the geometric configurations, received by the above method, as the matrix of factors of efficiency in the organization of the maintenance and repair. The condition of the optimization implies for the configuration and the dimensions of the matrix of correlation between the specialized and the universal stations would maximum approach the corresponding matrix of the ideal organization of the maintenance without the denial in servicing as well as down time of the station.

The optimization of the production a for the above algorithm requires to solve the three main issues in the following order (Egorova, 2002; Kreschenetskyi, 2003):

− processing of the form of expert questionnaire on previous determination of the number of specialized and universal stations;

− building the «master die» matrix for the organization of the technical maintenance of an automobile;

− choice of final correlation between the specialized and universal stations.

The processing of the form implies for the analysis of the ideas of specialists with the sufficient working experience as for the number of the specialized and the universal stations, their respectful provision depending on the input flow of the orders and the initial productivity of the car service center.

The methodic for the selection of the final structure of the manufacturing stations on the enterprise has the following succession:

− selection of the set correlation of the specialized and the universal stations from the previous analysis;

− modeling the variant of the operative control on the base of the above selection;

− building the matrix of factors for the organization of the system for this enterprise;

− comparison of the matrix of factors of the new organization accounting for the determined variant of operative control to the matrix of the input organization with the existing controlling system;

− determination of the module of the total deviation of each of the factors, comparing it to the previous value for the station to be formed;

− changing the structure of the organization due to the increase or decrease in the share of specialized stations, reconsidering the variant of controlling over the system of the repair.

This process should be repeated until the consideration of all the stations from the previous structure, changing the some of them.

The organization of the production is considered to be formed if the matrix of factors of station operation is close by its dimensions and configuration to the matrix of the corresponding factors for the ideal organization.

The block-schema of the above algorithm is presented on Fig. 2. Its realization on the PC allows quickly to form the manufacturing stations following the level of specialization on any automobile operating company.

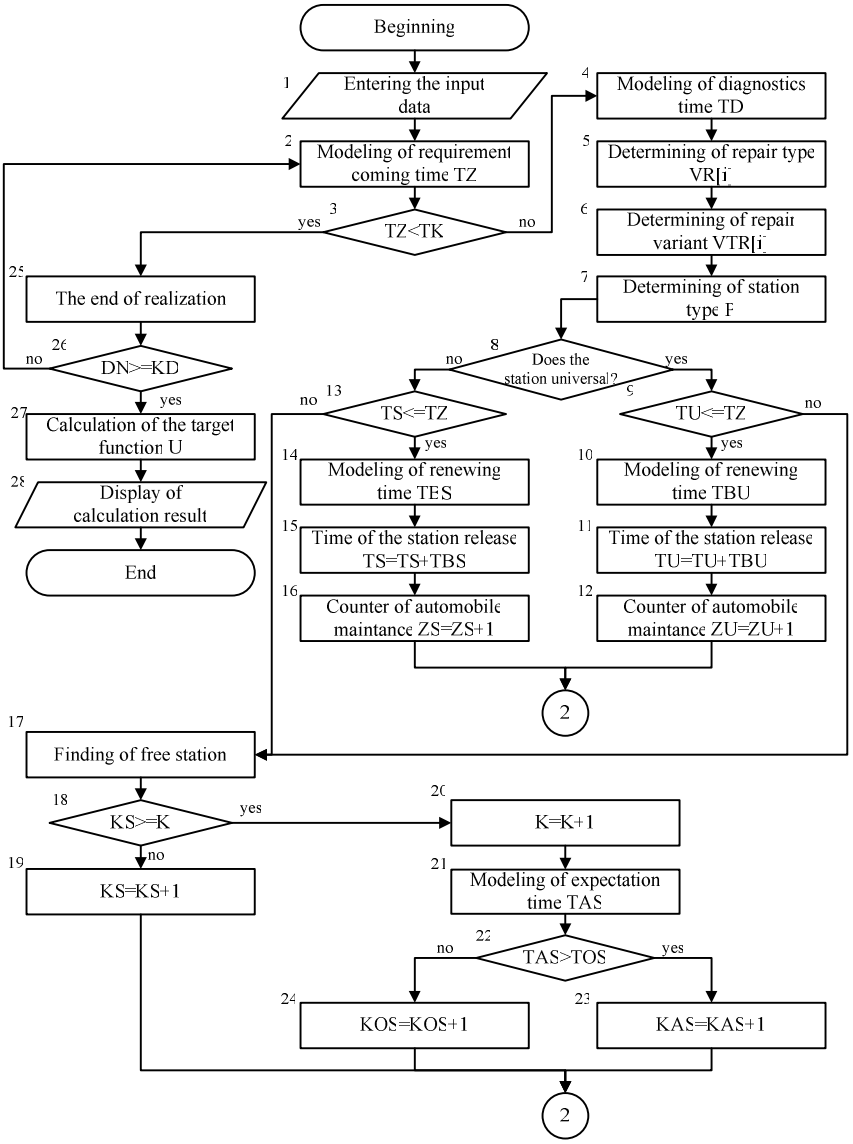


Fig. 2 − Generalized block- scheme of an algorithm for the functioning of the car service center.

The block scheme designates the varieties as follows:
− TD – test time;
− TK – time when the working day is over;
− K – total number of stations;
− P – type of repair station;

− VR[i] – repair type;
− KD – number of simulation days;
− KS – the total number of simulated stations on the enterprise;
− VTR[i] – rep[air variant;
− DN – the share of the automobiles share output, being diagnosed on the stations;
− TBS, TBU – maximum time for automobiles waiting on the specialized and universal stations;
− TS; TU – release time of the specialized and universal station;
− ZS; ZU – automobile number counter;
− TZ – time for processing the service order;
− KS – number of specialized stations on the car service center;
− TAS – current mean queuing delay of the automobile;
− TOS – maximum spent waiting time interval on the stations;
− KOS – number of automobiles attended;
− KAS – number of automobiles, which left due to the timing out;
− U – income received by an enterprise per 24 h.

The algorithm for the simulation of the enterprise's manufacturing activity is built with the consideration of the system approach to the issues under consideration.

The operation of the model begins with the introduction of the input data, which are formed in the result of the analysis of previous information, which characterizes the qualitative and quantitative structure of the input flow of the requirements, regularity of their entering the enterprise, the time histogram for automobile repair on the specialized on universal station. Further on, the model shall be tuned to the chosen controlling strategy of maintenance and automobile repair with the aim of analysis of its efficient use.

The manufacturing capacity of the repair station as well as its provision with the technological equipment shall be determined with the use of the determined calculation method.

Further on, there will be generated the twenty- four – hour flow of the requirements, composed after processing of previous information. After that, the flow of requirement shall be distributed depending on failures on the repair stations. There shall be fixed the time of application submission, simulated the time of repair, analyzed the previous analysis of the income, received from the repair of the automobile, and the automobile is registered for repair. Then there will be calculated the input number of automobiles to be repaired during the working day with the determination of the period for their staying on the car service center. After that there will be imitated the work on the formation of the production zone with the consideration of the twenty-four-hour time needed to repair the automobile. Later on, there will be determined the necessary value of productivity of each separate repair station, which is compared to the actual one. Depending on the conditions of the accepted strategy for the organization of the

maintenance and repair, there will be carried out the prognostication of the redistribution of the productive capacity as for the level of specialization of the repair stations. Then the process of the redistribution of the specialization share on the repair stations shall be simulated. This process considers the complete working hours of the repair station, efficiency of the equipment and accessories, qualification of the staff, total labor capacity, time, spent for repair.

In the end of each month there will be generated the monthly inequality in the supply of the orders flow in accordance with the regularity, established in the process of experimental researches on real car service centers.

During the whole simulation process there will be calculated the functional $U$ in conditions of the accepted strategy of the organization of automobile maintenance under the optimal variant of control. The strategy, the use of which leads to the maximum value of the target function, is considered to be the best one

Block 4 simulates the process of the execution of diagnostic influences on the diagnostics station. There will be determined the necessary working time and total expenses for the diagnostics of the car.

Block 5 simulates the process of choosing the necessary repair of the automobile. Herewith it is necessary to consider the possible influences which are at the command of the enterprise, age and the model of the automobile.

Block 6 simulates one of the four variants of maintenance and repair to be done.

Blocks 7 and 8 determine the type of the repair station; switch the model to the execution of technical influences on the specialized and universal stations.

Blocks 9 – 12 and 13 – 16 simulate the technological process of maintenance and repair of an automobile on the universal and specialized stations.

Blocks 17 – 20 realize the procedure of search for the «empty» station. That is, when at the moment of an order TZ the stations are occupied, the program control switches the model to the determination of т the holdover time TAS (block 21).

Block 22 verifies the conditions under which the automobile leaves the car service center due to the holdover time.

In the end of each working day of the enterprise there shall be determined the number of automobiles attended on each station, number of unattended automobiles which left, the total down time of the specialized stations due to the absence of orders and the intensity of automobiles repair per day (blocks 23 – 25).

During the simulation period there had been calculated the target function U, in the conditions of the accepted control strategy. The strategy, with which the total income from its functioning per day reached its maximum, was considered to be the best one.

Operator 42 determines the economic efficiency from the rational specialization of the manufacturing stations.

Block 43 determines the financial resources, necessary for the advanced specialization. The control then is transferred to the block 19.

Logic operator 44 verifies whether all the strategies had been considered. If so, the control is transferred to the logical block 45. In the other case – to block 7.

Logic operator 45 verifies whether all the variants of the specialization had been considered. If so, the control is transferred to the block 46, if not – the control is transferred to block 6.

Block 46 forms the array of the projects for the realization of the specialization strategy.

Block 47 transfers the calculation results for printing and simulation is over.

## 3. Conclusions

In the result of analysis and processing the results obtained in the process of model realization with different types of data, there had been made the following conclusions:

− the improvement of the specialisation level of repair stations is expedient with the significant number of orders on the maintenance and repair on the car service centre;

− the type of specialisation of this or the other station shall be established depending on the content of previous information;

− the level of the specialization of the station must be established depending on the share of orders placed, considering the types of works;

− the increase in number of repair stations is expedient only along with the high level of their specialization. This ensures the total satisfaction of customer's requirements for the performance of a service as well as causes the decrease in down time and denial in attendance;

− rational correlation between the number of repair stations, level of their specialization and the flow of the orders ensures the efficiency in functioning the automobile operating company with $U \rightarrow \max$.

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## CERCETAREA INFLUENŢEI NIVELULUI DE SPECIALIZARE AL POSTURILOR DE REPARAŢII PERMANENTE ASUPRA EFICIENŢEI FUNCŢIONĂRII COMPANIILOR DE AUTOSERVICE

(Rezumat)

A fost dezvoltată o diagramă simplificată a sistemelor de servicii de masă cu referire la întreprinderile de autoservice. S-a luat în considerare indicatorii de specializare ai unor forme diverse de organizare ale reparaţiilor auto la întreprinderile de autoservice. A fost dezvoltată o diagramă bloc generalizată pentru algoritmul de funcţionare a întreprinderii de autoservice.